AUTOMATION OF DISTRIBUTION KIOSKS
TECHNICAL AND FINANCIAL EVALUATION - "TYPICAL CASE STUDY"

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1-INTRODUCTION
Alexandria governorate has one of the most famous cities on the Mediterranean Sea. It has the major seaport of Egypt. It lies on the North West Coast of Egypt. Alexandria covers an area of 2819 Km$^2$; the occupied area is about 37.4% from the total area. It has a length of about 80-Km with max. depth of 5 Km and min. depth of 500M only.

Alexandria Electricity Distribution Company (AEDC) is a government-owned utility serving Alexandria City. AEDC is serving about 1.616 Million customers. The sold energy is $5.274 \times 10^6$ MWhr and the max. load is 1750 MW (industrial loads about 37.9%) with annual rate of increase about 4.3% (2003/2004).

For improving reliability of electrical power to cover the growth of loads and extension of occupied area for Alexandria governorate, many projects were applied to add new network components as Substations (S/Ss), Distribution Points (DPs), Primary Medium Voltage (MV) & Secondary Low Voltage (LV) cables, MV & LV Overhead Line, Distribution Transformers and Kiosks. In addition, another plan was applied for renewal of many parts of the network to get better performance. This plan was completed in 1997.

2-ALEXANDRIA DISTRIBUTION NETWORK AUTOMATION (DNA)
Network automation is required in Alexandria to get better results after network modification and to make use of the new investment. DNA is a great decision that has been taken by AEDC. Studies were started in 1993. The project was started in 1995 and was put in service in 1998. It costs about 56.2 million ₤E. (1 US$ = 6 ₤E).

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DNA is arranged in hierarchical configuration consisting of three Distribution Control Centers (DCCs) and a Supervisory Control Center (SCC). Each DCC provides controlling and monitoring of a definite part from the electrical network with no overlapping for decision responsibility using special communication protocol over radio communication links through Remote Terminal Units (RTU). In addition, it serves as a tool for optimal planning which results in economical operation and control. DNA would also be beneficial for accurate billing, quicker service restoration in case of fault, reduction in manpower …etc., contributing to healthy system development.

DCC is acting to fully collection and processing for all acquired data, as well issuing controls for the entire area of responsibility. Additionally, SCC provides for overall monitoring, without control, of the entire Alexandria electrical network. It has access to real-time data and display for all DCCs areas. It provides reporting capabilities that merge data from all DCCs.

There are 22 S/Ss, 98 DPs and 200 Distribution Transformer Rooms (Kiosks) under automation.

3-MAIN FUNCTIONS OF (DNA) SYSTEM
1-Acquisition, processing, monitoring and recording of Master Station (MS) and Remote End (RE) data (Digital Information and Analogue Measurement for the electrical network).
2-Detecting faults of MV cables at kiosks (Distribution Transformer Points).
3-Tele–control for Circuit Breakers (C.B.) at S/Ss and/or DPs and Load Break Switches (LBS) at Kiosks.
4-Power Application studies as Loss minimization, Load flow, Short circuit calculation, etc.
5-Integration with Geographical Information System (GIS).

4-EVALUATION OF DISTRIBUTION NETWORK AUTOMATION
There are many direct and indirect benefits as a result for applying DNA system and getting the valuable information from it.

4-1-Direct benefits
1-Improvement in reliability of supply through much quicker faults identification, isolation and restoration. This is not only increases sales, but also helps in better customer’s relation.
2-Drastic reduction of energy loss as a result of continuous monitoring for major customers for defective meters and energy theft.
3-Increasing system efficiency by optimizing the losses through real time operation of distribution system.
4-Better system planning by load survey and collection of adequate data.
5-Supervisory control of the system and its consequential benefits.
6-Sharp decreasing for unexpected accidents due to supplying the operator by all information about the outages and partial isolation of the network after system automation.

4-2-Indirect benefits
1-It provides a through overhauling of a typical distribution
system for bringing down the energy losses thereby making the power available to the more needs.

2-It helps for improving the system performance and techno-economic benefits of applying DNA.

3-Increasing the industrial production as a result of continuity of electrical power supply with very less interruption time.

4-Improving the quality of factories' production as a result of continuous supervision for electrical current and voltage of power supply and keeping them in the best qualification.

5-Creating a new well-trained working team in modern technology and a growing experience in installation and maintenance of Distribution Automation system components, software support, system studies, better reporting and training.

5-CASE STUDY

5-1-Introduction

The total number of distribution kiosks for Alexandria network is about 5700. AEDC has (8) maintenance centers for making the necessary switching operations, detecting the faulty MV cables and/or overhead lines which are joining these kiosks to supply sources and restoring supply again. Each center is located in the center of load area under its control. The nature of occupied areas (traffic jam or long distances from maintenance center to the faulty cable location) causes delay of supply restoration under manual operation system. SCADA system was applied only on 200 kiosks as a pilot project. The result of applying automation on these Kiosks is great. Detection of faulty MV cables, sending this information immediately to DCC, the action of isolating the faulty cable and restoring power supply to the isolated loop within few minutes are some of the advantages. It takes more than 45 minutes to be done in manual operation routine due to traffic jam or far distance from maintenance centers. Saving in time increases the sold energy and improves the power quality as new advantages. There are other direct advantages like improving voltage quality and loading levels of MV cables, saving in working teams and transport facilities due to remote operation, decreasing the routine maintenance programs and scheduled network partial isolation. There are indirect advantages like increasing the industrial production, improving its quality and increasing the national income. Applying SCADA system on all Kiosks is required to generalize these advantages. Modification of kiosks is required to be suitable for SCADA application. The modification includes changing the air isolated, manually operated isolator for each MV cable in the kiosk by a Ring Main Unit (RMU) with motorized Load Break Switch (LBS), SF6 gas isolated and a Pole mounted RTU (PRTU) associated with VHF radio as communication link using a special communication protocol. This process is so costly to be applied on all kiosks.

To get better results with lower cost, we have to find a solution to keep a suitable number of kiosks under automation to decrease the cost of automation and to get better results in case of loop isolation under faulty condition. The purpose of this study is to find a solution and to evaluate this solution for applying the SCADA system on the MV network kiosks for Alexandria city from technical and financial points of views.

The suggested solution under this study is to find the best location for the opening point for each loop to minimize the loop losses and cover the operational requirements to secure feeding of this loop. This could be done by applying the power application software package of the system.

Then we have to select two kiosks per each side of the loop to be under control. This means only one third of the faulty side of the loop containing the faulty cable will be isolated from DCC in case of tripping of its Circuit Breaker (C.B.) by protection. The Fault Detectors (FDs) of the rest of network kiosks’ cables will determine the direction of fault and the faulty cable. Alarms from FDs will be transmitted by GSM communication link to the responsible maintenance center. Maintenance team has to check the alarms, identify the MV faulty cable and isolate it. Then the rest of healthy part can be reenergized from DCC again. The total number of kiosks under control will be 1200 kiosks. There are 200 ones already under automation. So, the required number to be added is about 1000 kiosks.

5-2-Rules for kiosks’ selection to be under automation

5-2-1- From Operational point of view.
1- Single user Kiosk's (to apply Automatic Meter Reading AMR system as an additional advantage).
2- Distance from kiosk to maintenance center (far kiosks have priority).
3- VIP Loads in military areas or critical location's kiosks (can not be reached after sunset).
4- Nature of surrounded area (population density and traffic jam).
5- Kiosks, which have more than one direction for getting MV power, supply (multi-power source directions).
6- Each loop side has two kiosks under control to divide it to three parts (as per study).

5-2-2- From Control point of view.
1- Dimensions of transformer room (enough space to install control equipment).
2- Location (to get suitable communication signal level to nearest RTU).
3- Maximum number of kiosks per outstation (S/S or DP) not more than 20 ones (as system configurations).

6- COST OF APPLYING AUTOMATION ON MV NETWORK KIOSKS

6-1- Cost of modification of kiosks
1- Installation of Ring Main Unit (RMU), SF6 gas isolated and motorized LBS. It consists of 3 LBS panels for 3 MV cables and one LBS panel with shunt trip for Distribution Transformer.

Cost of RMU is about 45000 E£

2- Charger and batteries (20AH, 24 V DC as power supply for driving motors) and the required cables and connections.
Cost of Charger set is about 5000 E£

3- PRTU unit and communication accessories including
required cables for antenna and driving motors to PRTU.

Cost of PRTU is about 5500 CND$ (Canadian Dollar)
5500 CND$ = 26400 E£

\((1\text{CND$}=4.8\text{E£})\)

4- Fault Detectors with dry contact for MV cables (3 units) for each kiosk

FD unit price =250 E£.
Cost of 3 FDs is about \(3*250 = 750\) E£

6-2- Cost of modification of MV cable end termination at kiosks (3 cables)

MV cable end termination modification to be suitable for new Ring Main Unit

Cost of new termination per feeder is about 1000 E£
Cost of new termination per kiosk = 3*1000
= 3000 E£

6-3-Total Cost for modification of 1000 kiosks

Cost per kiosk = \(45000 + 5000 + 26400 + 3000 + 750\)
= 80150 E£

Number of kiosks to be under automation = 1000 kiosks
Total cost of 1000 kiosks = 80150 * 1000
= 80150000 E£

6-4- Cost of transmitting faulty loop FDs' alarms to maintenance center

There are 8 maintenance centers for Alexandria MV electrical network. The FDs alarms from the rest of kiosks after applying automation will be transmitted to the proper maintenance center.

Number of kiosks, which are being under FDs’ alarm supervision, are equal to:

Total No. of kiosks – No. of kiosks under automation
= 5670 – 1200
= 4470 kiosks

Cost of FDs for the rest of kiosks = 4470 * 3 * 250
= 3352500 E£

Cost of alarm transmission service per maintenance center
= 200000 E£

Cost for 8 maintenance center = 8 * 200000
=1600000 E£

Total cost = Cost of FDs + Cost of alarm transmission
= (1600000 + 3352500)
= 4952500 E£

6-5- Total cost for applying automation on MV kiosks for Alexandria network

Total cost for applying automation on MV kiosks
= Cost of modification of 1000 kiosk
+ Cost of transmitting faulty loop’s alarms
=80150000 + 4952500
= 85102500 E£

7-1-Direct saving

7-1-1-Equipment saving.
The existing equipment in kiosks, which will be under automation, can be used in new installed kiosks, which do not required automation. Reinstalled equipment is air isolated MV Bus Bar and isolators. Average cost of removed equipment to be used in new rooms out of automation is about 2000 E£.

Saving from 1000 kiosks is \(2000*1000 = 2000000\) E£

7-1-2- Cost of saved energy.

I-Cost of saved energy due to Network Troubles.

<table>
<thead>
<tr>
<th>Control Center</th>
<th>No. of S/S's</th>
<th>No. of DP's</th>
<th>No. of Automated kiosks</th>
<th>Total No. of Kiosks</th>
</tr>
</thead>
<tbody>
<tr>
<td>East</td>
<td>9</td>
<td>27</td>
<td>77</td>
<td>1646</td>
</tr>
<tr>
<td>Middle</td>
<td>8</td>
<td>23</td>
<td>82</td>
<td>1519</td>
</tr>
<tr>
<td>West</td>
<td>5</td>
<td>48</td>
<td>41</td>
<td>2505</td>
</tr>
<tr>
<td>Total</td>
<td>22</td>
<td>98</td>
<td>200</td>
<td>5670</td>
</tr>
</tbody>
</table>

TABLE (1) - Remote End Configuration of DNA System

Average load per feeder= 103.18 Amps.
Average time for loop isolation and supply restoration per year is about 22 hours approximately in manual operation regime.

Average energy lose per feeder
\(= (3)^{0.5} * 103.2585 * 11000 * 0.8 \times 22 / 1000000\)
\(= 34.63 \text{ MWHrs}.\)

Average saving after applying automation per feeder
\(= (2/3 * 34.63)\)
\(= 23.1 \text{ MWHrs}.\)

Total annual saving in the network = 23.1 * 1284
\(= 29660 \text{ MWHrs}.\)

Average price per 1 KWhr = .016 E£
Annual Cost for Saving Energy = 0.16* 29660 * 1000
\(= 4745600 \text{ E£}.\)

II- Cost of saved energy due to Maintenance Saving.

Periodic maintenance for kiosk per year is two times; each one takes about three hours and half an hour for switching operations (7 hours per kiosk yearly).

Average saved energy per kiosk
\(= (5.274 * 1000000 * 7) / (5670 * 8760)\)
\(=743 \text{ KWHrs}.\)

Annual cost of saved energy for 1000 kiosk
\(= 743 * 0.16 * 1000\)

7-SAVING DUE TO APPLYING KIOSKS AUTOMATION:

The study will evaluate the gain from the major advantages which are mentioned in item (5-1).
7-1-3- Maintenance saving.
The scheduled or routine maintenance for traditional kiosks is two times per year. The new installed Ring Main Units (RMU) are maintenance free (SF6 gas isolated and motorized).
1- Cost of routine maintenance (spare parts and consumable materials) is about 200 £E per each maintenance time.
   Annual saving for 1000 kiosks is about (200 * 2 * 1000) = 400000 £E
2- Labor cost for routine maintenance:
   - Required maintenance number is (2* 1000) = 2000 maintenance times
   - Working team required for maintenance consists of 3 persons from maintenance team and one from operation team (4 persons).
   - Required groups in the same time is (2000/300) = 7 groups
   - Total number of working persons is (4 * 7) = 28 persons
   - Average monthly salary per person is 800 £E
   Annual saving of labor cost is about (28 * 800 *12) = 268800 £E
   Annual maintenance saving = 400000 + 268800 = 668800 £E

7-1-4-Saving for transport (vehicles).
I- For Maintenance. Number of saved trips due to maintenance reduction is 2000 trips for maintenance group. It means saving about 15% from annual transport cost for maintenance team.
   Annual saving for transport of maintenance teams is about 40000 £E

II- For Operation. Number of monthly switching operations is about 25000 times which required about 12000 trips for operation team to be done. It means saving about 250 trips per month, i.e. 3000 trips annually (about 20% from annual transport cost for operation team).
   Annual saving for transport of operation teams is about 60000 £E
   Annual saving for transport is about 100000 £E
   Total direct saving = Cost for Saving Energy +Maintenance saving +Transport saving
   = 4934400 + 668800 + 100000
   = 5703200 £E

7-2-Indirect saving
There are about 273 feeding cables to the industrial loads. There are 141 direct feeding cables from S/Ss or DPs to industrial loads and are controlled by the SCADA system. The rest of feeding cables (132 cables) are through the network. These cables will be included in our study.
The saving energy after applying control system
   = 23.1 * 132
   = 3049.2 MWHrs
There is about 70% from this energy to be used in the production purpose.
The average saving for industrial energy is about (3049.2 * 0.7) = 2134.44 MWHrs.
The cost of lost energy for industrial load by international standards is about (1 to 3 Euro/KWHr). So, the indirect saving due to insure power supply to the industrial load can be reached to 2134440 Euros as per lowest rate of international standards.
   It means the indirect saving is about (2134440 *7) =14941080 £E
   (1Euro=7 £E)

7-3-Total annual saving
Total annual saving = Direct saving + indirect saving
   Direct saving = 5703200 £E
   Indirect saving = 14941080 £E
   Total annual saving = Direct saving + Indirect saving = 20644280 £E

8- COST REFUND
The Total cost is about 85102500 £E
Reinstalled equipment saving = 2000000 £E
Final cost = total cost – reinstalled equipment saving
   = 85102500 – 200000
   = 83102500 £E
   Annual saving = 20566900£E
   Period for refund =Final cost / annual saving
   = 83102500 / 20644280
   = 4.026 Years

9-CONCLUSION
Applying SCADA system on all kiosks is required but the cost is so high. To get better results with lower cost, we suggested a solution to keep a suitable number of kiosks under automation to decrease the cost of automation and to get better results in case of loop isolation under faulty condition. The study evaluates the solution for applying the SCADA system on the MV network kiosks for Alexandria city from technical and financial points of views. The solution under this study is to select two kiosks per each side of the loop to be under control. This means only one third of the faulty side of the loop containing the faulty cable will be isolated from DCC in case of tripping of its C.B. by protection. The Fault Detectors of the rest of network kiosks’ cables will determine the direction of fault and the faulty cable. Maintenance team will isolate the faulty cable. Then the isolated part can be re-energized from DCC. The total number of kiosks under control will be 1200 kiosks.
The study shows the cost of modification of kiosks to be under control from DCC and evaluates the refund from most of direct and indirect benefits after applying the SCADA system on MV network kiosks. The direct and indirect benefits from this application can cover the cost of kiosks’ automation as per the suggested solution within about 4
There are many advantages which have not been included in the financial evaluation, but adding valuable technical support to the distribution system.

10- REFERENCES

AEDC Technical & Commercial Reports:


Project documents:


Papers from conference Proceeding (Published):


11- AUTHOR BIOGRAPHY

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He was born in Alexandria, Egypt on Aug. 17, 1949. He graduated from Faculty of Engineering Alexandria Univ. on 1972. Khaled has a Master degree from Alex Univ. in 1978. He has many published papers in many conferences in Middle East area and Europe.

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