البرنامج المصرى – الألمانى لادارة مياه الشرب و الصرف الصحى
Egyptian-German Water and Wastewater Management Program

Report on:

Review of the Power Factor Correction Potential at Salheya, Deshna & Nag Hamady Water Treatment Plants in Qena

Dr. Ahmed A.R. Khozam

April 2010

gtz

PN 2006.2063.3; VN 81087234

STRENGTHENING PROVISION OF SERVICES IN QENA AND PROMOTING APPROPRIATE RURAL SANITATION OPTIONS IN EGYPT

Review of the Power Factor Correction Potential at Salheya, Deshna & Nag Hamady Water Treatment Plants in Qena

Dr. Ahmed A.R. Khozam

April 2010

RODECO CONSULTING GMBH

GOPA WORLDWIDE CONSULTANTS

CONTENTS

Executive Summary **1**
1. Objectives and Methodology **2**
2. Al Salhaya WTP and Intake (known as Sheikh Husein Intake) **3**
2.1 Plant Description 3
2.2 Electrical Plant Situation 3
2.2.1 Treated Water Plant 3
2.2.2 Raw Water Plant (Al-Sheikh Husein Intake) 4
2.2.3 Electrical Parameters and Energy Consumption 4
2.3 Data Analysis 7
2.4 Equipment Design 7
2.4.1 The Treated Water Plant 7
2.4.2 The "Al-Sheikh Husein" Intake (Raw Water Plant) 8
2.5 Financial Analysis 8
2.5.1 Al-Salhya Water Treatment Plant 8
2.5.2 Al-Sheikh – Husein Intake 8
2.6 Conclusions and Recommendations 9
3. Deshna Water Treatment Plant **10**
3.1 Plant Description 10
3.2 Electrical Plant Situation 10
3.3 Data Analysis 13
3.4 Equipment Design 13
3.5 Financial Analysis 14
3.6 Conclusions and Recommendations 14
4. Nag Hamady Water Treatment Plant **15**
4.1 Plant Description 15
4.2 Electrical Plant Situation 15
4.3. Data Analysis 19
4.4 Equipment Design 19
4.5 Financial Analysis 20
4.6 Conclusions and Recommendations 21
5. Overall Conclusions and Recommendations **22**

Appendix

A Capacitor Installation Drawings

B Bill od Quantities and Equipment Specifications

C Electrical Tarrifs

D Survey of Electrical & Mechanical plant at Salheya WTP

E Earthing, design, installation and testing – Training Material

EXECUTIVE SUMMARY

This study was undertaken in January 2010 as a follow up to the Energy Efficiency & Reducing Power Factor Cost report produced by Andreas Friemel in 2009 within the frame of the TC support to Qena Company for Water and Wastewater (QCWW).

The follow-up study reviewed the previously collected data for Salheya, Deshna and Nag Hamady Water Treatment Plants, identified the actual costs of PF correction equipment (purchased in Egypt) and recalculated the pay-back periods for the initial investments required to achieve savings indented. A bill of quantities for equipment and specifications has been prepared for each site.

The table below summarises the costs, potential savings, investment costs and pay-back periods for each site. More detailed information on the site electrical loads, etc. is contained in the main report.

Summary Table of Annual Site PF Costs & Savings					
Name	Current PF	PF Penalties LE	Potential Savings including bonus (.95PF)	Cost of PF Equipment	Estimated Payback Period
Salheya WTP	.76	78,776	95,656	157,600	20 months
Salheya Intake PS	.8	24,000	31,200	60,000	23 months
Deshna WTP	.77	58,923	72,521	150,000	24 months
Nag Hamady WTP	.78	143,133	121,339	183,000	18 months
Totals		304,832	320,716	550,600	

The above figures show that **savings of up to 320,716 LE per annum can be achieved with an initial investment of 550,600 LE** in providing suitable PF correction equipment at the 3 sites studied with a maximum **payback period of 2 years**, assuming that the electricity supply contract is renegotiated at Nag Hamady WTP.

The contracted power of Nag-Hammadi WT plant is 1350 kW, while the maximum demand reached 1887 kW in 2007/2008. In line with the Egyptian tariff, a penalty of LE 50,051 was imposed on the plant, equivalent to the difference between contracted power and maximum demand. To remove this penalty, actions have to be taken to increase the contracted power to at least 2000 kW by negotiating with the electricity supply company.

A special survey was carried out at Salheya WTP to identify poor installation, damaged equipment or missing safety measures, covering earthing, electrical isolation, barriers, etc. safety signs and mechanical protection. The results of this survey are shown in Appendix D (in Arabic) and have been used to support the repairs and maintenance being carried out at Salhaya WTP in preparation for the TSM audit.

Other general findings showed that at all sites there is an over capacity of transformers which results in poor energy efficiency. Recommendations are therefore made for each site on how to remove transformers from service.

Training was provided to 25 QCWW technical staff in the design, installation and testing of earthing networks as recommended in the Energy Efficency & Reducing Power Factor Cost report produced by Andreas Friemel in April 2009. The training took place at the Kenouz Training centre over 5 days, the list of attendees and a copy of the training material is shown in Appendix E.

It should be noted that the WTPs at Armant and Esna were excluded from this survey due to recent changes in the governorate boundaries. The WTP at Haswhya was not surveyed due to extensive refurbishment and construction at the site, which made it impractical to carry out the necessary tests. In addition, at the request of the QCWW the WTPs at Qus and Qeft were not included in this study as they have already started to install PF correction equipment on site.

1. Objectives and Methodology

The objective of this study is to improve the power factor (PF) at the 3 selected sites to a targeted value 0.95 to realise potential savings and receive a bonus payment from the electricity supply company as well as to improve electrical safety particularly with regard to earthing of equipment.

Thus the main tasks of the study were to;

1) Review the data collected regarding plant electrical power efficiency, costs of power-factor correction equipment & installation/commissioning and update as necessary
2) Develop a cost analysis report for improving power factor at the selected QCWW sites
3) Carry out a survey of plant at Salheya WTP, Qena City, to verify if E&M equipment meets the following criteria:
    - Earthing
    - Safety isolation (Electrical) – barriers, etc.
    - Safety signs
    - Mechanical protection – i.e. machine guards, etc.
4) Provide advice to the Technical Department in the form of training on specifying, selecting and installing appropriate power factor correction equipment and designing and testing earthing systems as recommended in the Energy Efficency & Reducing Power Factor Cost report by Andreas Friemel.

A questionnaire was developed and issued to sites to collect current information on load, power and costs followed up by site visits to assess the current situation. Single line diagrams of the HV/transfomer network were made for each site to help understand the layout and arrangement of equipment.

To facilitate the specification and purchase of the necessary PF correction equipment a bill of quantities was prepared for each site. Costs and payback calculations were assessed using current Kwh tariff costs, penalty charges and metered readings from sites.

In addition, a survey was carried out of Salheya WTP to identify hazardous, missing or faulty electrical and safety equipment to support the TSM process (see Appendix D).

Further, training and advice was provided to the QCWW Technical Support Sector to improve the design, installation and system testing skills of 25 engineers.

The findings of the study are shown in a separate section for each site, which contains detailed quantities, costs and background to the improvement of PF or other cost saving measures; the related bills of quantities are shown in Appendix B.

2. Al Salhaya WTP and Intake (known as Sheikh Husein Intake)

2.1 Plant Description

Al-Salhya Water Treatment plant is located in Qena city and consists of two plants: the raw water pumping plant (station) and the treated water pumping plant. The raw water is supplied from the Nile through raw water pumps to the inlet distribution chamber which feeds water to clarifiers and filters and is then pumped to water tanks, from which the treated water is pumped to the grid of some districts in Qena governorate through the treated water pumps.

The production capacity of the plant ranges from 45000 m³ / day in winter season to about 80000 m^3 /day in summer months (May to September). The pumping head is approximately 60 m.

2.2 Electrical Plant Situation

Al-Salhya WT plant is supplied by two 11 kV feeders, one from Al-Salhya substation and the other (stand-by) from Al-Towayrat substation.

2.2.1 Treated Water Plant

The single line diagram (S.L.D) of the Al-Salhya WT plant is illustrated in Figure 1. Large pumps in the treated water plant are operated at the 3.3 kV level through two transformers, each rated 2.5 MVA- 11/3.3 kV. It was clear from site visits that the two transformers are in service and lightly loaded. The low voltage loads are supplied by energy through two transformers, each rated 2.0 MVA, 11/0.4 kV. Thus the total capacity of installed transformers in the WT plant is 9 MVA.

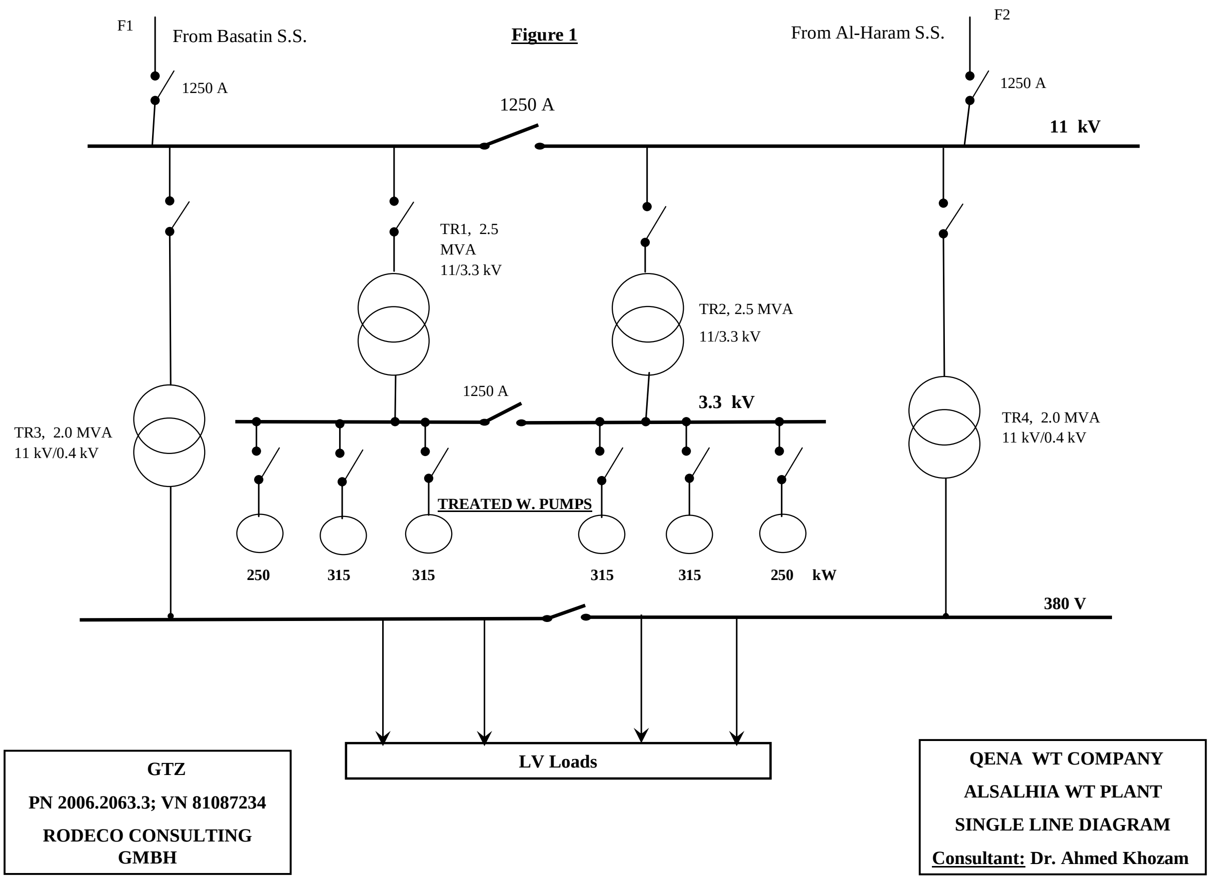
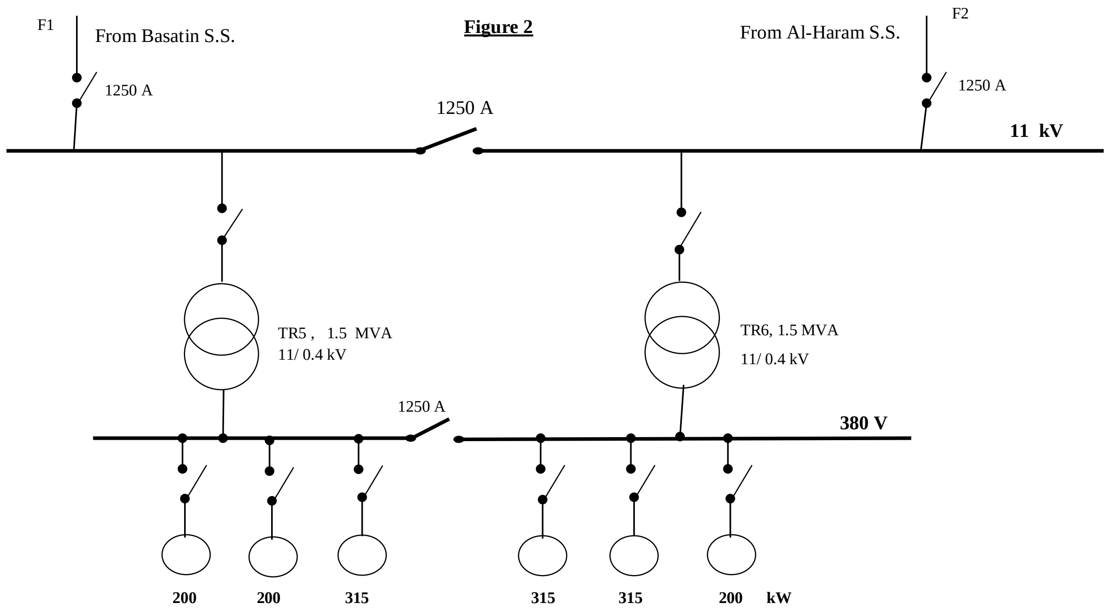


Figure 1 – Single Line Diagram of the Al-Salhya Water Treatment Plant

2.2.2 Raw Water Plant (Al-Sheikh Husein Intake)

The single line diagram (S.L.D) of the "Sheikh Husein" Intake (raw water plant) is illustrated in Figure 2 below. The plant is supplied by electricity at the 11 kV level from the same feeders supplying the WT plant. The raw water loads are operated at 380 volt level, through two transformers, 1.5 MVA, 11/0.4 kV each. Most of the time, the two transformers are in operation, and the bus-coupler is opened.

Figure 2



RAW WATER . PUMPS

GTZ
PN 2006.2063.3; VN 81087234
RODECO CONSULTING GMBH

QENA WT COMPANY
AL-SHIEKH HUSEIN (RAW WATER) INTAKE
SINGLE LINE DIAGRAM
Consultant: Dr. Ahmed Khozam

2.2.3 Electrical Parameters and Energy Consumption

With reference to data recorded in the electricity bill issued by the Upper Egypt Electricity Distribution Company (UEEDC), the major electric parameters are as follows for the years 2007/2008 and 2008/2009:

*	Contracted Power (kW)	=	4050 kW (at 0.9 PF)
*	Maximum demand (2007/2008)	=	868 kW
	(2008/2009)	=	1152 kW
*	Annual energy consumption (2007/2008)	=	4323614 kWh
*	Annual energy consumption (2008/2009)	=	5258772 kWh
*	Average annual power factor of treated water plant (2007/2008)	=	0.77
*	Average annual power factor of treated water plant (2008/2009)	=	0.76
*	Average annual power factor of raw water plant	=	0.80

*	Energy Cost (2007/2008)	=	LE 836402
*	Energy Cost (2007/2008)	=	LE 1125377
*	Fixed Charge (2007/2008)	=	LE 92702
	(2008/2009)	=	LE 131214
*	Total Electricity Bill (2007/2008)	=	LE 929104
*	Annual Power Factor Penalty of treated water plant (2007/2008)	=	LE 54467
*	Estimated Annual Power Factor Penalty of treated water plant (2008/2009)	=	LE 78776
*	Annual Power Factor Penalty of raw water plant (2007/2008)	=	LE 24000

The monthly energy consumption during 2007/2008 is shown in Table 1 and illustrated in Figure 3.

Table 1 - Monthly Consumption and Maximum Demand of Al-Salhya W.T. Plant (2007/2008)

Month	Consumption	Max. Demand	Energy Cost	Fixed Charge	Total Bill
	(kWh)	(kW)	(LE)	(LE)	(LE)
Jul	363936	868	66600	7465	74065
Aug	380280	868	69591	7465	77056
Sep	352212	868	64455	7465	71920
Oct	356892	868	70308	7812	78120
Nov	336108	868	66213	7812	74025
Dec	358080	868	70542	7812	78354
Jan	362892	868	71490	7812	79302
Feb	345336	868	68031	7812	75843
Mar	363720	868	71653	7812	79465
Apr	361620	868	71239	7812	79051
May	379908	868	74842	7812	82654
Jun	362630	868	71438	7812	79250
Total	**4323614**		**836402**	**92702**	**929104**

Source: Upper Egypt EDC and Al-Salhya Water Treatment Plant, based on a questionnaire submitted by the consultant

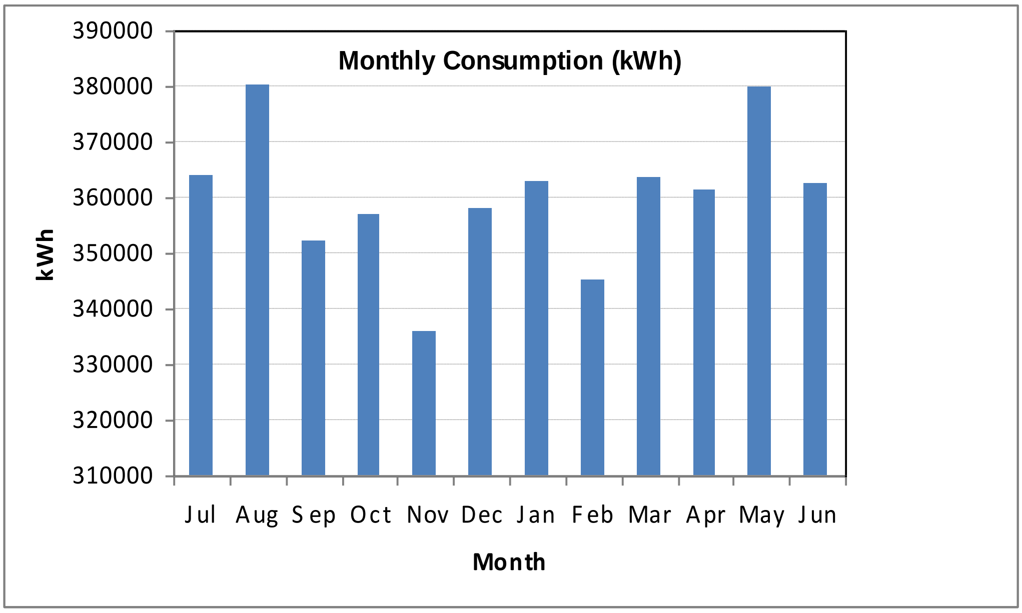


Figure 3 - Monthly Consumption of Al-Salhya WT Plant (2007/2008)

Major Loads

Table 2 shows the major loads in both Al-Salhya WT plant and "Al-Sheikh Husein" intake. Al-Salhya WT plant has six pumps of rated power (4 x 315 kW + 2 x 250 kW) operated at the 3.3 kV. The total installed power of the treated water pumps is 1760 kW and the normal mode of operation of the 3.3 kV pumps is as follows:

- Three pumps in winter (2 x 315 + 1 x 250) kW.
- Four pumps in summer season (2 x 315 + 2 x 250) kW.

The raw water pumps installed at "Al-Sheikh Husein" intake are: 3 x 315 kW and 3 x 200 kW, of total installed capacity 1545 kW. The pumps are operated at the 380 V level with the following schedule:

- Three pumps in winter (2 x 200 + 1 x 315) kW, and
- four pumps in summer season (2 x 315 + 2 x 200) kW

Table 2 – Major Loads in Al-Salhya Water Treatment Plant and Sheikh Husein Intake

Location	Qty	Rate (kW)	Total (kW)	RPM	Operating Voltage	PF
Treated water pump	4	315	1260	1480	3.3 kV	0.73
Treated water pump	2	250	500	---	3.3 kV	---
Raw water pump	3	315	945	1480	380 V	0.8
Raw water pump	3	200	600	1480	380 V	0.8
Washing pump	2	110	220	1480	380 V	0.8
Air compressor	2	75	150	1865	380 V	0.8
Total Loads			**3675**			

Source: Al-Salhya WT plant, based on Questionnaire submitted by the consultant.

2.3 Data Analysis

Data provided by Upper Egypt Electricity Distribution Company indicates that the average annual power factor of Al-Salhya WT plant was 0.77 for the year 2007/2008 and decreased to 0.76 for 2008/2009. The penalty imposed on the plant as a result of the low PF was estimated for the two years at LE 54467 and LE 63463, respectively.

The maximum demand of Al-Salhya WT plant was 1151 kW during the last year, while the average demand is approximately 500 kW, giving an average annual load factor of approximately 43%. This low load factor indicates that the plant performance is not efficient.

The total rating of installed transformers in Al-Salhya WT plant is 9 MVA, while the peak demand recorded in 2008/2009 is 1151 kW, equivalent to 2803 kVA at 0.76 PF. This created a situation of lightly loaded transformers (maximum 31%), resulting in bad efficiency and lower power factor as well as more transformer losses. This problem can partially be solved by de-energizing two transformers: one 2.5 MVA used for medium voltage pumps and the second 2.0 MVA used for low voltage loads.

With respect to the raw water plant named Sheikh Husein Intake, the data provided by UEEDC indicates that the average annual PF is 0.8, and the imposed penalty was LE 24005 for the year 2007/2008. The maximum demand of the intake is 860 kW and the estimated annual energy consumption is approximately 2437 MWh, costing about LE 480000.

Similar to Al-Salhya WT plant, the two transformers (2 x 1.5 MVA) installed in the intake are lightly loaded with maximum 36% at 0.8 PF. During the site visit, it was therefore recommended to de-energize one transformer and close the bus-coupler between the two transformers.

2.4 Equipment Design

The design of the capacitor banks is aiming to raise the power factor from 0.76 in the water treatment plant to 0.95, and from 0.8 in the raw water plant (Sheikh Husein Intake) to 0.95. The design is based on data provided by UEEDC, a questionnaire submitted to the two plants, and site visits.

2.4.1 The Treated Water Plant

The design approach for the treated water plant considers the compensation of the reactive power at both the medium and low voltage levels. The calculations of reactive power corrective equipment are based on the following:

- Plant data and energy survey
- The maximum and average demands
- Transformers rating
- Mode of operation and diversity factor at each load centre
- The expected increase in load
- The targeted power factor (0.95).

To improve the PF at Al-Salhya WT plant, it is recommended to install a capacitor bank of total power rating 400 kVAR, connected at the outgoing bus-bar of the two transformers (2 x 2.5 MVA) at the 3.3 kV level. The bank consists of four steps, each step 100 kVAR, delta connected, as illustrated in Appendix A. Only one regulator, six steps, will be installed for both sides of the capacitor banks.

The bill of quantities and specifications of the capacitor bank components are given in Appendix B.

For the reactive power compensation at the low voltage level (380 V, 50 Hz), it is recommended to install a capacitor bank of total power 360 kVAR, consisting of two sections of 180 kVAR each. Each section consists of 3 steps, rated 60 kVAR each. The capacitor banks are connected to the outgoing bus-bar of the two transformers (2 x 2.0 MVA).

2.4.2 The "Al-Sheikh Husein" Intake (Raw Water Plant)

Two transformers are installed in Al-Sheikh Husein intake of rated power 1.5 MVA. The two transformers are tied by bus-couples, and, most of the time, each transformer caries its own loads. However, they are lightly loaded and the staff is reluctant to load one transformer and de-energize the other on a regular basis.

The average annual power factor of the plant is 0.8, and its maximum demand reached 860 kW. To raise PF to, at least, 0.95, it is recommended to install 400 kVAR, divided into 8 steps, each step 50 kVAR, as illustrated in Figure 4. The banks will be connected to the outgoing bus-bar at the 380 V level. A 12 step regulator is recommended in this case.

2.5 Financial Analysis

2.5.1 Al-Salhya Water Treatment Plant

Power Factor Improvement

The average annual PF for Al-Salhya WT plant was 0.77 in 2007/2008 and decreased to 0.76 in 2008/2009. The amount of penalty paid in 2007/2008 was LE 54467, increased to LE78776 due to the decrease in PF, increase in energy tariff, and increase in electricity consumption.

The implementation of PF improvement project will eliminate this penalty. Additionally, the target of this study is raise the PF to 0.95, which will allow the plant to get a PF bonus, estimated as follows (see Appendix C):

$$\textbf{Bonus} = \frac{0.95 - 0.92}{2} \times \text{annual kWh} \times \text{LE / kWh}$$

The amount of bonus is approximately LE 16,880 according to the new rate of consumption.

Payback Period

The total recommended compensating reactive power for the Al-Salhya WT plant is 760 kVAR. Compensation for MV (3.3 kV) loads needs 400 kVAR of cost around LE 100,000, and compensation for LV (380 V) loads needs 360 kVAR of cost approximately LE 57,600. The total cost of equipment, including capacitors, regulators and all other components is estimated at LE 157,600. This gives an expected simple payback period of about 2 years, due to the elimination of the annual penalty. With bonus, the payback period is reduced to 1.65 years (20 months).

2.5.2 Al-Sheikh – Husein Intake

The average power factor of "Al-Sheikh Husein" intake was 0.8 in 2007/2008, which implies an amount of penalty equal to LE 24,000 per year.

Payback Period

Calculations have shown that a capacitor of 400 kVAR is required to raise the PF from 0.8 to 0.95, of estimated cost around LE 60,000. The payback period, in this case, is 2.5 years. At power factor 0.95, the plant can get a bonus estimated at LE 7,200. In this case, the payback period is decreased to approximately 1.9 years (23 months).

2.6 Conclusions and Recommendations

The results of power factor improvement study at **Al-Salhya Water Treatment Plant** and **"Sheikh Husein" Intake** lead to the following conclusions:

- All six transformers in the two plants are lightly loaded. The performance of the electric network and power factor could be improved by feeding all loads by three transformers (two in Al-Salhya WT plant and one in Al-Sheikh Husein intake) instead of six. This would improve efficiency, power factor and reduce transformer losses.
- It is also important to check the ground systems, and conduct measurements to evaluate the performance of electrical network, measure neutral currents, and examine the loading conditions of the transformers.
- The expected results of power factor improvement project implementation are:

Item	**Al-Salhya WT Plant**		**Al-Sheikh Husein Intake**	
	Before PF Improvement	**After PF Improvement**	**Before PF Improvement**	**After PF Improvement**
Average annual PF	0.76	0.95	0.8	0.95
Maximum active power (kW)	1151	1151	860	860
Maximum apparent power (kVA)	1515	1212	1075	905
Annual consumption (kWh)	5258772		2436548	
Power factor penalty (LE)	78776	---	24000	---
Installed capacitor banks (kVAR)	----	760	----	400
Cost of equipment (LE)	157600		60000	
Savings due to removal of penalty (LE)	78776		24000	
Payback period due to removal of penalty	2 years		2.5 years	
Total savings (LE)	95656		31200	
Payback period due to total savings	20 months		23 months	

3. Deshna Water Treatment Plant

3.1 Plant Description

Deshna Water Treatment plant supplies Deshna city and surroundings with fresh water. The actual production capacity is approximately 34,500 m^3 per day in winter and increases to 52,000 m^3 per day in summer.

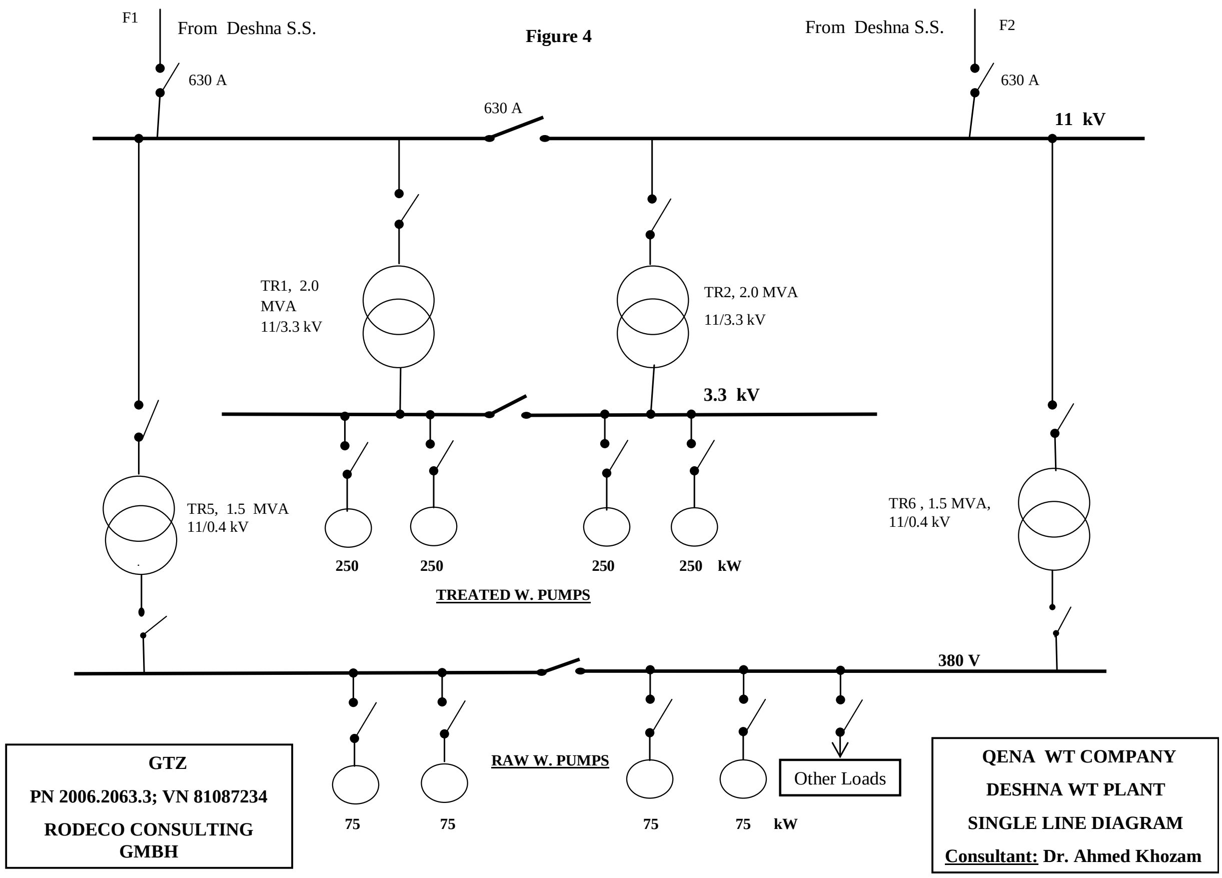
3.2 Electrical Plant Situation

Deshna WT plant is supplied by two 11 kV feeders, both from Deshna substation.

The single line diagram (S.L.D) of Deshna WT plant is illustrated in Figure 4. The pumps for treated water are operated at the 3.3 kV level through two transformers, each of rated capacity 2.0 MVA- 11/3.3 kV. Normally, the two transformers are in operation, and the bus-coupler between them is opened.

The raw water pumps and other loads are operated at the 380 V level, and are supplied by energy through two transformers, each rated 1.5 MVA, 11/0.4 kV. Thus the total capacity of installed transformers in Deshna WT plant is 7 MVA.

Figure 4



Electrical Parameters and Energy Consumption

With reference to data recorded in the electricity bill of 2008/2009 issued by Upper Egypt Electricity Distribution Company (UEEDC), the major electric parameters are as follows:

* Contracted Power (kW) = 3500 kW (at 0.9 PF)
* Maximum demand = 840 kW
* Annual energy consumption = 4236000 kWh
* Average annual power factor = 0.77
* Energy Cost = LE 906504
* Fixed Charge (2007/2008) = LE 95760
* Total Electricity Bill = LE 1002264
* Annual Power Factor Penalty = LE 58923

The monthly energy consumption during 2008/2009 is shown in Table 3 and illustrated in Figure 5.

Table 3 - Monthly Consumption and Maximum Demand of Deshna WT Plant (2008/2009)

Month	Consumption	Max. Demand	Energy Cost	Fixed Charge	Total Bill
	(kWh)	(kW)	(LE)	(LE)	(LE)
Jul	422000	840	90308	7980	98288
Aug	380000	840	81320	7980	89300
Sep	402000	840	86028	7980	94008
Oct	344000	840	73616	7980	81596
Nov	386000	840	82604	7980	90584
Dec	292000	840	62488	7980	70468
Jan	324000	840	69336	7980	77316
Feb	316000	840	67624	7980	75604
Mar	308000	840	65912	7980	73892
Apr	342000	840	73188	7980	81168
May	324000	840	69336	7980	77316
Jun	396000	840	84744	7980	92724
Total	**4236000**		**906504**	**95760**	**1002264**

Source: UEEDC and Deshna WT plant, based on a questionnaire submitted by the consultant

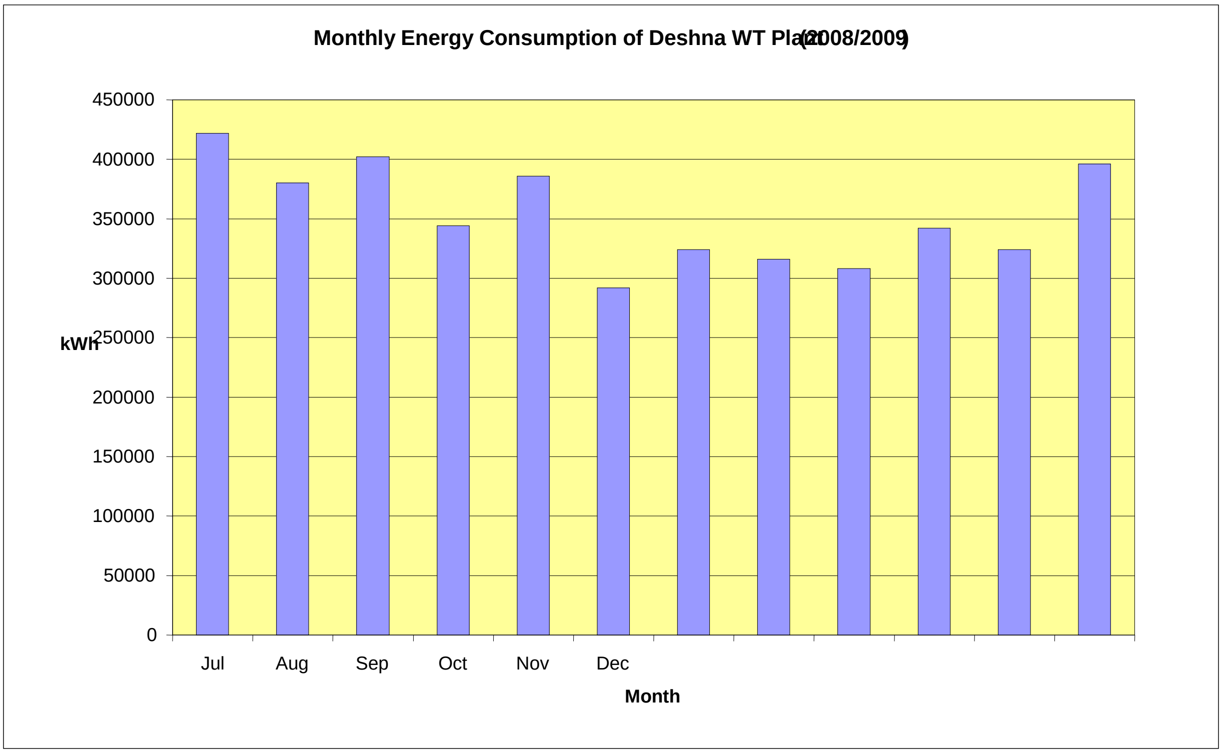


Figure 5 - Monthly Consumption of Deshna WT Plant (2008/2009)

Major Loads

Table 4 shows the major loads in Deshna Water Treatment plant. The plant incorporates four pumps of rated power 250 kW each, operated at MV 3.3 kV, 50 Hz. The total installed power of the treated water pumps is 1,000 kW. Normally two pumps are operated and the other two are stand-by. In summer, the operating pumps could be increased to three.

For the intake, four raw water pumps, each of rated power 75 kW, are installed and are operated at low voltage (380 V, 50 Hz). In winter, two pumps are in operation and the other two are stand-by, while three are in operation and one stand-by in summer.

Table 4 – Major Loads in Deshna Water Treatment Plant

Location	Qty	Rate (kW)	Total (kW)	RPM	Operating Voltage	PF
Treated water pump	4	250	1000	1478	3.3 kV	---
Raw water pump	4	75	300	1500	380 V	---
Washing pump	2	110	220	987	380 V	---
Air compressor	2	75	150	2840	380 V	0.78
Cleaning pump	2	75	150	---	380 V	---
Total Loads			**1820**			

Source: Deshna WT plant, based on a questionnaire submitted by the consultant.

3.3 Data Analysis

Data provided by the UEEDC indicates that the average annual power factor recorded in 2008/2009 for Deshna WT plant was 0.77. The penalty paid by the plant due to low PF was estimated at LE 58,923.

The contracted power of Deshna WT plant is 3500 kW, at 0.9 PF, while the peak demand of the plant reached 840 kW in 2008/2009. This indicates that the capacity of power allocated to the plant is much higher than its maximum demand. In this case, Deshna plant should modify its contracted power to the value acceptable by regulations (for example, to decrease it to 1.5 MW at 0.9 PF).

The average demand of Deshna plant during 2008/2009 was approximately 484 kW, giving an annual load factor of approximately 58%. This low load factor is higher than Al-Salhya and Nag-Hammadi WT plants; however, it is still low for efficient use of energy.

The total rating of installed transformers in Deshna WT plant is 7 MVA, while the peak demand recorded in 2008/2009 was 840 kW, equivalent to 1091 kVA at 0.77 PF. Hence, the maximum loading of istalled transformers is approximately 16% only. It is recommended to use two transformers only instead of four, one (2 MVA) for MV pumps and the other (1.5 MVA) for LV loads. The other two transformers could be switched off.

3.4 Equipment Design

The design of the capacitor banks is aiming to raise the power factor from 0.77 to 0.95. The design is based on data provided by the UEEDC, a questionnaire submitted to the plant through the project as well as a walk-through audit.

Compensation of the reactive power will be considered at both the medium and low voltage levels. The calculations of reactive power corrective equipment are based on the following parameters:

- The maximum and average demands
- Transformers rating.
- Mode of operation and diversity factor at each load centre.
- The expected increase in load.
- The targeted power factor (0.95).

MV Transformers TR1 and TR2:

To improve power factor at the outgoing busbars of the two MV transformers, TR1 and TR2 (2.0 MVA,11/3.3 kV), it is recommended to install a capacitor bank of total power rating 360 kVAR, divided into two sections, each section 180 kVAR consisting of 3 steps, 60 kVAR each. Each step is connected in delta as shown in Appendix A. Only one regulator, six steps, will be installed for both sides of the capacitor banks.

LV Transformers TR3 and TR4:

To improve power factor at the low voltage level (380 V, 50 Hz), it is recommended to install a capacitor bank of total power 400 kVAR at the outgoing bus-bar of the two transformers TR3 and TR4. The bank consists of two sections, 200 kVAR each; each section consists of 4 steps; each step is rated 50 kVAR as shown in Appendix A. It is recommended to use a 12 step regulator to control the switching of capacitors according to load variations.

The bill of quantities and specifications of the capacitor bank components are presented in Appendix B.

3.5 Financial Analysis

Power Factor Improvement

The average annual PF for Deshna WT plant was 0.77 in 2008/2009. The estimated amount of penalty paid for this year was LE 58923. The implementation of PF improvement project will eliminate this penalty. Moreover, by improving PF up to a targeted value 0.95, the plant can get a PF bonus, estimated as follows (see Appendix C):

$$\textbf{Bonus} = \frac{0.95 - 0.92}{2} \times \text{annual kWh} \times \text{LE / kWh}$$

The amount of the bonus is approximately LE 13,598, based on the rate of consumption of 2008/2009.

Payback Period

The total recommended compensating reactive power for the Deshna Water Treatment Plant is 760 kVAR, from which 360 kVAR is used to compensate the reactive power at 3.3 kV, with an estimated cost of about LE 90000. Compensation at low voltage will need 400 kVAR of cost around LE 60,000. The total cost of equipment, including capacitors, regulators and all other components is estimated at LE 150,000.

The expected simple payback period due to the elimination of the annual penalty, is approximately 2.55 years. Including bonus, the total amount of savings is estimated at LE 72,521, resulting in a payback period of about 2 years.

3.6 Conclusions and Recommendations

1. The power factor improvement study at **Deshna Water Treatment Plant** led to the following results:

	Before PF Improvement	**After PF Improvement**
Average annual PF	0.77	0.95
Maximum active power (kW)	840	840
Maximum apparent power (kVA)	1091	884
Annual consumption (kWh)	4326000	4109700
Power factor penalty (LE)	58923	0
Installed capacitor banks (kVAR)	0	760
Cost of equipment (LE)	150000	
Savings due to removal of penalty (LE)	58923	
Payback period due to removal of penalty	2.55 years	
Bonus for 0.95 PF (LE)	13598	
Total savings (LE)	72521	
Payback period due to total savings	2.0 years	

2. The study also revealed other energy efficiency options:

- The estimated Specific Energy Consumption (SEC) for Deshna WT plant is about 0.82 kWh/m^3, which is higher than the typical SECs in Egyptian WT plants, and much higher best practices on the international level (SEC of best practices ranges from 0.1 to 0.3). The energy performance of the plant should be investigated through benchmarking.
- The contracted power of Deshna WT plant is 3,500 kW, which is much higher than the maximum demand (840 kW). This is usually not acceptable by the electric utility regulations. It is recommended to lower the contracted power to around 1.5 MW by negotiating with the electricity supply company.
- The total capacity of the installed transformers in Deshna WT plant is 7 MVA, and the annual peak demand is 1091 kVA at 0.77 PF. Thus the maximum loading of the four transformers is approximately 16%; this condition of lightly loaded transformers produces high losses, low efficiency and low power factor. Load management is needed based on further investigation and measurements.

4. Nag Hamady Water Treatment Plant

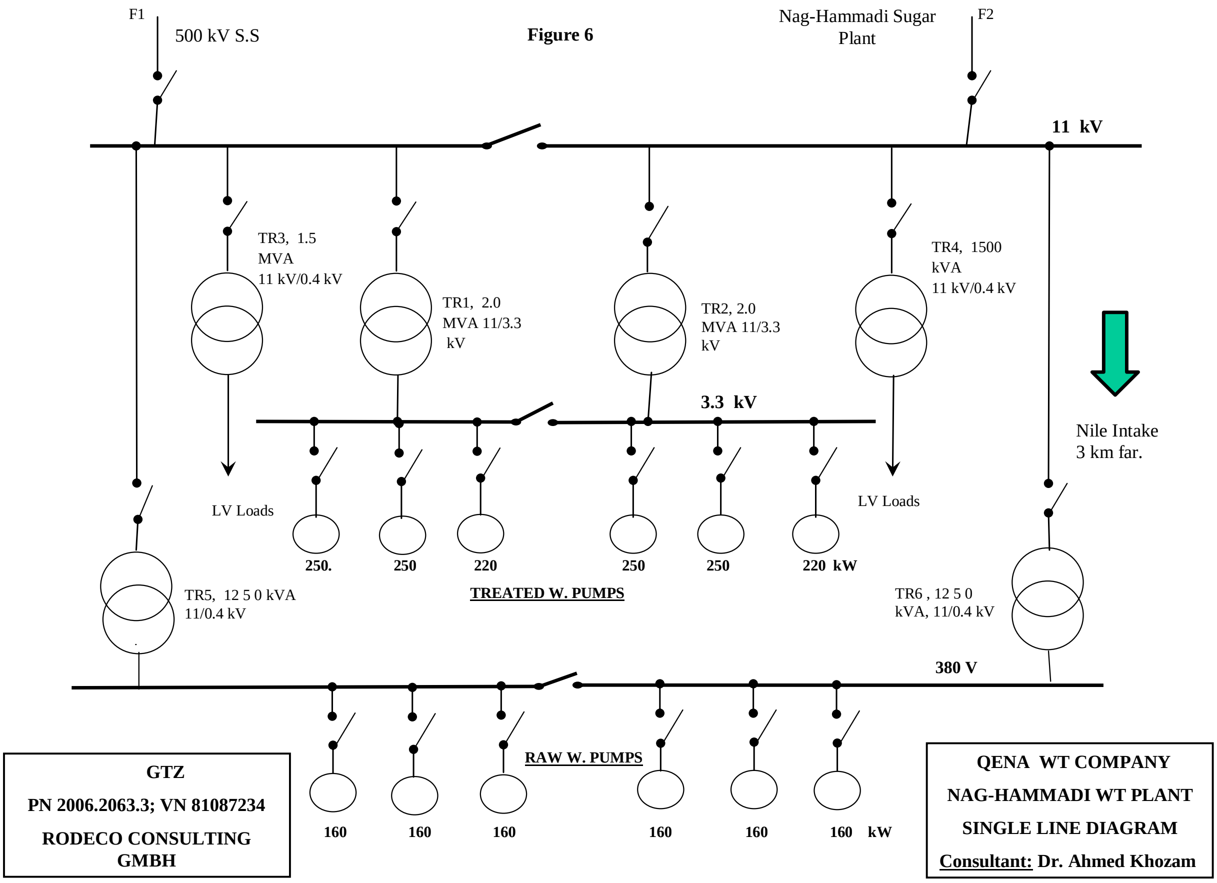
4.1 Plant Description

Nag-Hammadi Water Treatment plant started its first phase of producing potable water in 1999, with a production capacity of approximately 35,000 m^3 per day. This capacity has been doubled to 70,000 m^3 per day in 2008. The raw water is supplied from the Nile through Nag-Hammadi raw water plant, which is located 3 km far from the WT plant. The plant supplies Nag-Hammadi city and other surrounding villages with potable water through treated water pumps of rated power ranging from 300 to 335 HP.

4.2 Electrical Plant Situation

Nag-Hammadi WT plant is supplied by two 11 kV feeders, one from the sugar plant of Nag-Hammadi, and the other (stand-by) from the “500 kV - Nag-Hammadi” substation. The single line diagram (S.L.D) of the Al-Salhya WT plant is illustrated in Figure 6 on the next page.

There are four transformers of rated capacity: 2 x 2.0 MVA + 2 x 1.5 MVA. The first two transformers - 11/3.3 kV- supply power to the MV pumps for treated water. Normally, the two transformer are in operation, and the bus-coupler between them is opened. The low voltage loads of the treated water plant, such as washing pumps, compressors, lighting, etc. are supplied by energy through the other two transformers, 1.5 MVA – 11/0.4 kV.



The estimated Specific Energy Consumption (SEC) for Nag-Hammadi WT plant is 0.8 kWh/m^3, which is higher than the typical SECs in the Egyptian WT industry, and much higher than best practices achieved internationally (ranging from 0.1 to 0.3).

The raw water plant (intake) of Nag-Hammadi is located 3 km from the treated water plant and is supplied by electricity at the 11 kV level from the same substations supplying the WT plant. The raw water pumps and other loads are operated at the 380 volt level, through two transformers of rated power 1,250 kVA, 11/0.4 kV each. Most of the time, the two transformers are in operation and the bus-coupler is opened.

Therefore, the overall capacity of installed transformers in both treated water and raw water plants is 9.5 MVA.

Electrical Parameters and Energy Consumption

With reference to the monthly bills of 2007/2008 and 2008/2009 issued by Upper Egypt Electricity Distribution Company (UEEDC), the major electric parameters are as follows:

*	Contracted Power (kW)	=	1350 kW (at 0.9 PF)
*	Maximum demand (2007/2008)	=	1887 kW
*	Maximum demand (2008/2009)	=	1560 kW
*	Annual energy consumption (2008)	=	8513375 kWh
*	Annual energy consumption (2008/2009)	=	8771960 kWh
*	Average annual power factor (2007/2008)	=	0.78
*	Average annual power factor (2008/2009)	=	0.80

*	Energy Cost (2007/2008)	=	LE 1883794
*	Fixed Charge (2007/2008)	=	LE 17927
*	Total Electricity Bill (2007/2008)	=	LE 1901721
*	Annual Power Factor Penalty (2007/2008)	=	LE 93082
*	Annual Penalty of maximum demand (2007/2008)	=	LE 50051
*	Estimated PF Penalty of 2008/2009	=	LE 93860

The monthly energy consumption during 2008 is shown in Table 5 and illustrated in Figure 7.

Table 5 - Monthly Consumption and Maximum Demand of Nag-Hammadi WT Plant (2008)

Month	Consumption	Max. Demand	Energy Cost	Fixed Charge	Total Bill
	(kWh)	(kW)	(LE)	(LE)	(LE)
Jan	596072	1887	127219	17927	145146
Feb	560136	1887	120140	17927	138067
Mar	5654192	1887	163496	17927	181423
Apr	654928	1887	138814	17927	156741
May	747120	1887	156975	17927	174902
Jun	755639	1887	158652	17927	176579
Jul	808288	1560	173259	14820	188079
Aug	805816	1560	172772	14820	187592
Sep	779352	1560	167559	14820	182379
Oct	777928	1560	181282	14820	196102
Nov	694896	1560	163513	14820	178333
Dec	679008	1560	160113	14820	174933
Total	**8513375**		**1883794**	**196479**	**2080273**

Source: Upper Egypt EDC and Nag-Hammadi water treatment plant, based on a questionnaire submitted by the consultant

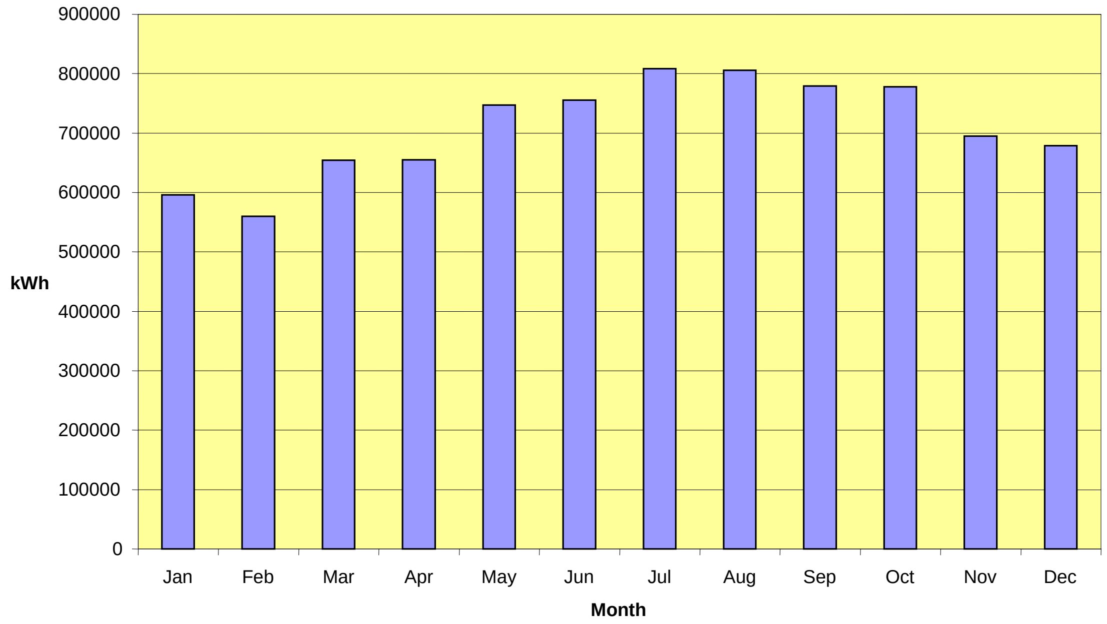


Figure 7 - Monthly Consumption of Nag-Hammadi WT Plant (2008)

Major Loads

Table 6 shows the major loads in Nag-Hammadi Water Treatment plant. The plant icorporates six pumps of rated power (4 x 250 kW + 2 x 220 kW) operated at MV 3.3 kV, 50 Hz. Thus the total installed power of the treated water pumps is 1440 kW. Normally the treated water pumps are operated in the following mode:

In winter: three pumps (2 x 250 + 1 x 220 kW), from 1:0 am to 6:0 am.

Four pumps (2 x 250 + 2 x 220 kW), from 6:0 am to 1: am, next day.

In summer: four pumps (3 x 250 + 1 x 220 kW), 24 hours.

Six pumps of rated power (6 x 160 kW) are installed at the raw water intake, and operated at low voltage (380 V, 50 Hz) according to the following mode:

- Four pumps (160 kW each) are operated from 6:0 am to 1:0 am the next day, and
- Two pumps (160 kW each) from 1:0 am to 6:0 am.

Table 6 – Major Loads in Nag-Hammadi Water Treatment Plant

Location	Qty	Rate (kW)	Total (kW)	RPM	Operating Voltage	PF
Treated water pump	4	250	1000	1478	3.3 kV	---
Treated water pump	2	220	440	1478	3.3 kV	---
Raw water pump	6	160	945	1500	380 V	---
Washing pump	2	110	220	987	380 V	---
Air compressor	1	8	8	2840	380 V	0.78

Other loads (blowers, cleaners, lighting, etc)	---	---	100			
Total Loads			**2713**			

Source: Nag-Hammadi WT plant, based on a questionnaire submitted by the consultant.

4.3. Data Analysis

Based on data provided by the UEEDC, the average annual power factor recorded in 2007/2008 for Nag-Hammadi WT plant was 0.78; during 2008/2009 the PF increased to 0.8. The penalty imposed on the plant due to low PF was estimated at LE 93,083 for the year 2007/2008 and slightly increased to LE 93,860 in 2008/2009 due to increased electricity consumption.

The contracted power of Nag-Hammadi WT plant is 1,350 kW, at 0.9 PF, while the peak demand reached 1,887 kW in 2007/2008, i.e. the peak demand exceeds the contracted by 537 kW (39%). In 2008/2009, the peak demand decreased to 1560 kW, i.e. still more than the contracted power by 210 kW (16%). According to Electric Utility regulations, this situation is not acceptable, and the plant has to pay demand charge penalty because the maximum demand exceeds the contracted power by more than 5%. For 2007/2008, the penalty paid by Nag-Hammadi WT plant was LE 50,051, and for 2008/2009, it is estimated at LE 23,940.

To save the demand charge penalty, the plant should increase its contracted power to at least 2,000 kW.

The average demand consumed during 2007/2008 was 972 kWW, while the maximum demand recorded during the same year was 1887, giving an annual load factor of approximately 52%. This low load factor is an indicator of bad performance of the electric network.

The total rating of installed transformers in Nag-Hammadi WT plant is 9.5 MVA, while the peak demand recorded during 2007/2008 was 1887 kW, equivalent to 2,419 kVA at 0.78 PF. Thus the maximum loading of istalled transformers is about 26%. This condition of lightly loaded transformers introduces more losses, lower efficiency, and a lower PF. It is therefore recommended to use three transformers only and de-energize the other three for better performance of the electric network.

4.4 Equipment Design

The design of the capacitor banks aims to raise the power factor from 0.78 (worst case) to 0.95. The design is based on data provided by the UEEDC, a questionnaire submitted to the engineering staff of the plant as well as a site visit by the consultant.

Compensation of the reactive power will be carried out at both the medium and low voltage levels. It will take into consideration the maximum demand, transformer ratings, load characteristics and expected extension.

MV Transformers TR1 and TR2:

For the two MV transformers, TR1 and TR2 (2.0 MVA, 11/3.3 kV), the power factor will be improved at the outgoing busbars of the two transformers as shown in Appendix A. It is recommended to install a capacitor bank of total power rating 360 kVAR, connected, divided into two sections, each section 180 kVAR consisting of 3 steps, each step rated 60 six steps, will be installed for both sides of the capacitor banks.

The bill of quantities and specifications of the capacitor bank components are given in Appendix B.

LV Transformers TR3 and TR4:

For the two LV transformers, TR3 and TR4, 1.5 MVA, 11/0.4 kV each, the corrective reactive power is located at the outgoing 380 V bus-bar. The recommended value of the capacitor bank is 300 kVAR, divided into two sections, 150 kVAR each. Each section consists of 3 steps, rated 50 kVAR each. The capacitor bank for TR3 and TR4 is illustrated in Appendix A.

LV Transformers TR5 and TR6:

For the raw water plant (transformers TR5 and TR6), it is recommended to install a 320 kVAR capacitor bank (2 x 160 kVAR), consisting of 8 steps, 40 kVAR each, as shown in Appendix A. It is also recommended to use a 12 step regulator.

4.5 Financial Analysis

Power Factor Improvement

The average annual PF for Nag-Hammadi WT plant was 0.78 in 2007/2008 and increased to 0.8 in 2008/2009. The amount of penalty paid in 2007/2008 was LE 93,082, slightly increased to LE 93,860 due to increased consumption and energy tariff.

The implementation of the PF improvement project will eliminate this penalty. Moreover, improvement of power factor to 0.95 will allow the plant to get a PF bonus, estimated as follows (see Appendix C):

$$\textbf{Bonus} = \frac{0.95 - 0.92}{2} \times \text{ annual kWh x LE / kWh}$$

The amount of bonus is approximately LE 28,257 for the year 2008/2009.

Payback Period

The total recommended compensating reactive power for Nag-Hammadi WT plant is 980 kVAR. At the MV (3.3 kV) level, the required capacitor bank is 360 kVAR of cost around LE 90,000. Compensating reactive power at the LV (380 V) level is estimated at 620 kVAR of cost around LE 93,000. Thus the total cost of equipment, including capacitors, regulators and all other components is estimated at LE 183,000. The expected simple payback period in this case is approximately 2 years, due to the elemination of the annual penalty. With a PF bonus, the total amount of savings is LE 121,339 and the payback period is reduced to 1.5 years (18 months).

Modification of Contracted Power

Nag-Hammadi WT plant in 2007/2008 paid a demand charge penalty of LE 50,051 due to the increased peak demand with respect to contracted power. This penalty is usually imposed if the peak demand exceeds the contracted power by more than 5%.

Prompt action should be taken by the plant to modify the contracted power to 2,000 kW instead of 1,350 kW. Consequently, the plant would save this penalty.

If the cables are capable of carrying the increased capacity (most likely so), no investment cost is required and an immediate payback period can be achieved.

4.6 Conclusions and Recommendations

- The results of power factor improvement study at Nag-Hammadi WT plants and design of capacitor banks lead to the following conclusions:

Item	Nag-Hammadi WT Plant	
	Before PF Improvement	After PF Improvement
Average annual PF	0.78	0.95
Maximum active power (kW)	1887	1887
Maximum apparent power (kVA)	2419	1986
Annual consumption (kWh)		
Installed capacitor banks (kVAR)	----	980
Cost of equipment (LE)	18,3000	
Savings due to removal of penalty (LE)	93,082	
Payback period due to removal of penalty	2 years	
Total savings (LE)	12,1339	
Payback period due to total savings	18 months	

The above results are based on data of 2007/2008 electric bill.

- Transformers in Nag-Hammadi WT plant are lightly loaded. It is recommended to disconnect two transformers and de-energize the other two. This will improve efficiency, power factor and reduce transformer losses.
- Since the maximum demand in Nag-Hammadi plant exceeds the contracted power by more than 5% (39% in 2007/2008), it is recommended to increase the contracted power from 1,350 kW to at least 2,000 kW. This will save about LE 50,000 every year.
- It is important to conduct benchmarking for evaluating the energy efficiency performance of the plant.

5. Overall Conclusions and Recommendations

Conclusions

Based on the 3 plants surveyed there is great potential for savings amounting to:

- 320,716 LE per annum from PF correction and bonuses from the electrical supply company
- 50,000 LE per annum from renegotiating the electricity supply agreement at Deshna WTP

This represents total savings of 370,716 LE per annum after investing 550,600 LE with a maximum pay back period of 2 years.

With the bill of quantities for PF correction equipment and the specifications contained in this report it would be easy to arrange for a contractor to install the necessary equipment and QCWW to start gaining these savings in their operating costs for these plants.

Switching off lightly loaded transformers can also represent some savings, and it also gives the advantage of reducing the potential fault current should a short circuit or earth fault develop.

Recommendations

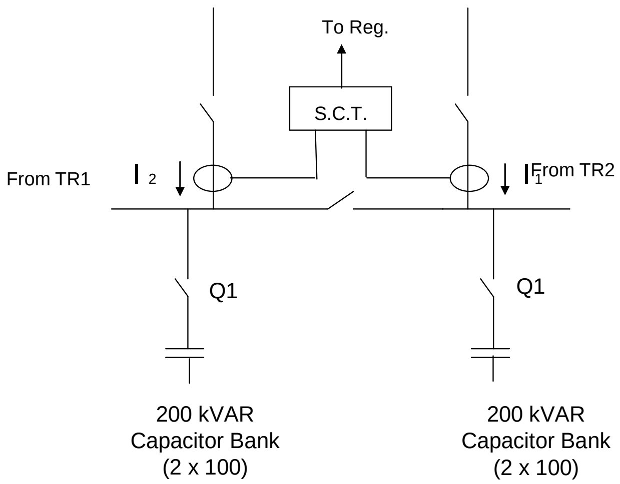
1) Install the as detailed in this report to achieve savings of 320,000 LE per annum
2) Negotiate with the electrical supply company to modify Nag Hamady WTP's contracted power demand (currently 1,350 Kw) to at least 2,000 Kw to remove the penalty of 50,000 LE per annum
3) Isolate lightly loaded transformers at the plants as specified in this report
4) Lower the contracted power to around 1.5 MW by negotiation with the electricity supply company for Deshna WTP to conform to the Electricity Supply regulations for Egypt.

APPENDIX A

CAPACITOR BANKS INSTALLATION DRAWINGS
(Al Salhya)

APPENDIX A1

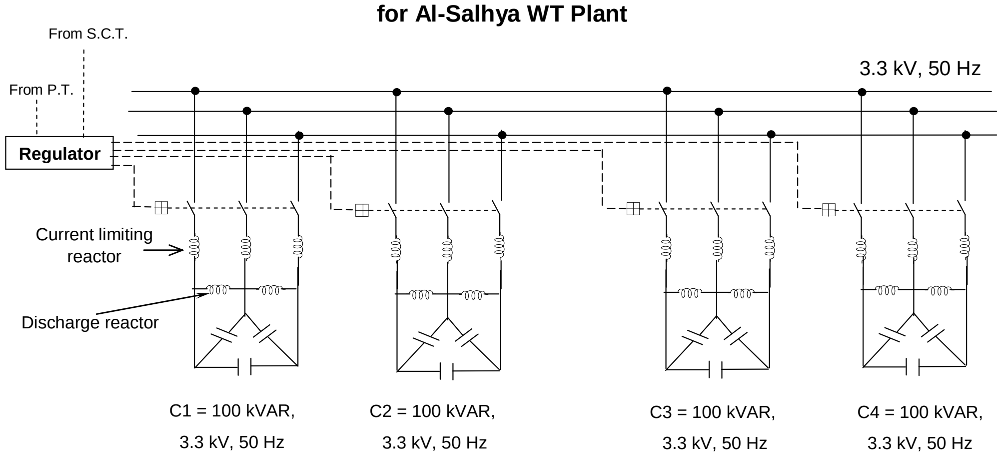
Configuration of 400 kVAR, 3.3 kV, 50 Hz Capacitor Bank for Al-Salhya WT Plant



QENA WATER COMPANY	**MV 400 kVAR CAPACITOR BANK**		*Sponsored By:*
			GTZ
	Date	01/03/2010	**RODECO CONSULTING GMBH**
	Drawn By	Marwa	
AL-SALHYA WT PLANT	Checked By	A.K.	*Consultant:*
	Approved By		**Dr. Ahmed Khozam**
	Figure	A1	

APPENDIX A2

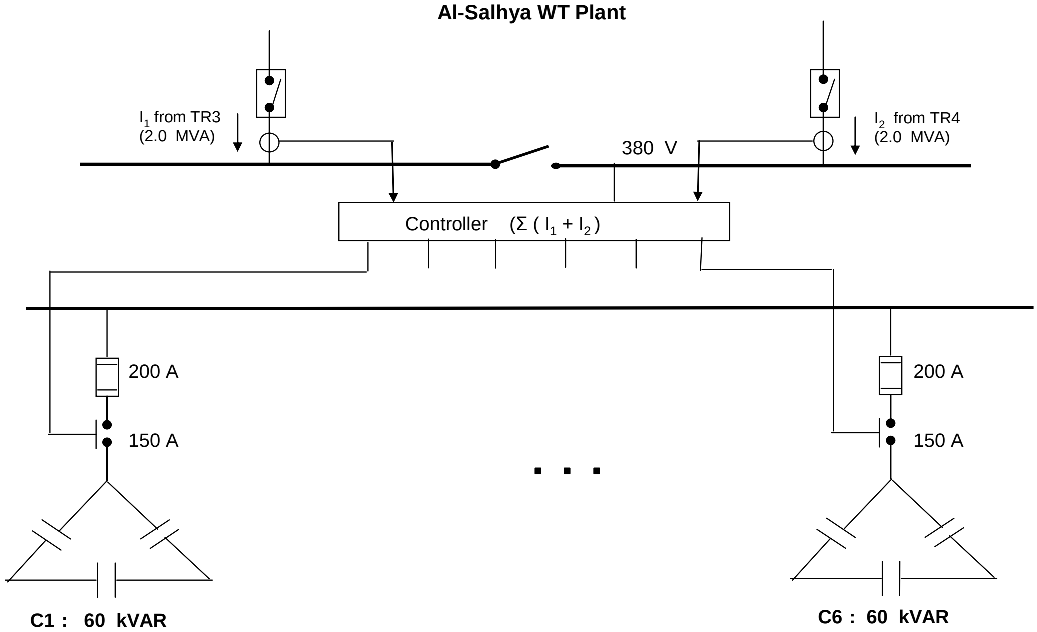
Medium Voltage 400 kVAR Capacitor Bank for Al-Salhya WT Plant



QENA WATER COMPANY	**400 kVAR, 3.3 kV, 50 Hz CAPACITOR BANK**		*Sponsored By:*
			GTZ
	Date	01/03/2010	**RODECO CONSULTING GMBH**
	Drawn By	Marwa	
AL-SALHYA W.T. PLANT	Checked By	A.K.	*Consultant:*
	Approved By		**Dr. Ahmed Khozam**
	Figure	A2	

APPENDIX A3

Low Voltage 360 kVAR Capacitor Bank for Al-Salhya WT Plant

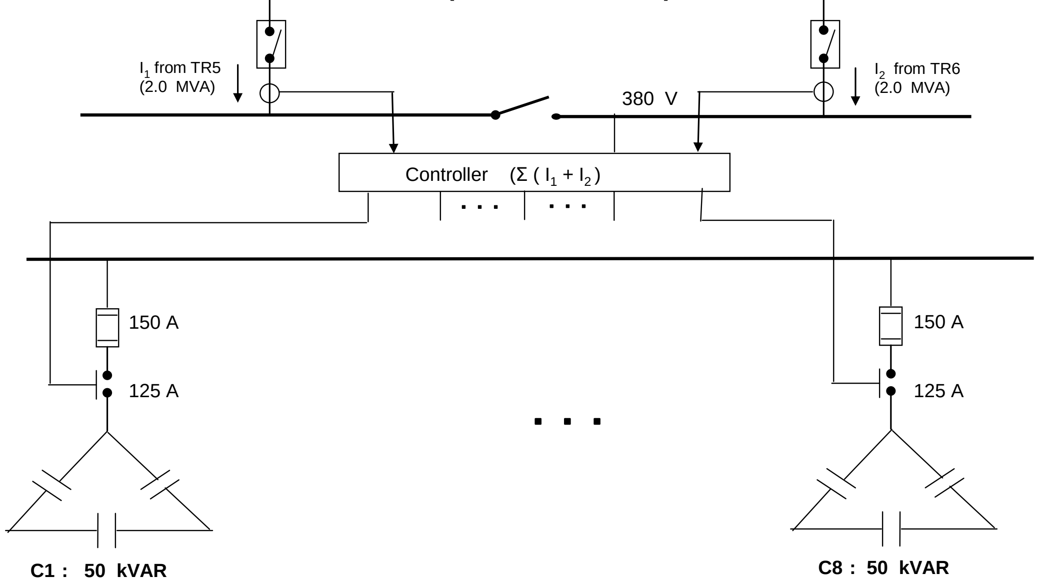


QENA WATER COMPANY	MV 400 kVAR CAPACITOR BANK		*Sponsored By:* GTZ
	Date	01/03/2010	RODECO CONSULTING GMBH
	Drawn By	Marwa	
AL-SALHYA W.T. PLANT	Checked By	A.K.	*Consultant:*
	Approved By		Dr. Ahmed Khozam
	Figure	A3	

APPENDIX A4

Low Voltage 400 kVAR Capacitor Bank for

Raw Water (Al-Sheikh Husein) Intake

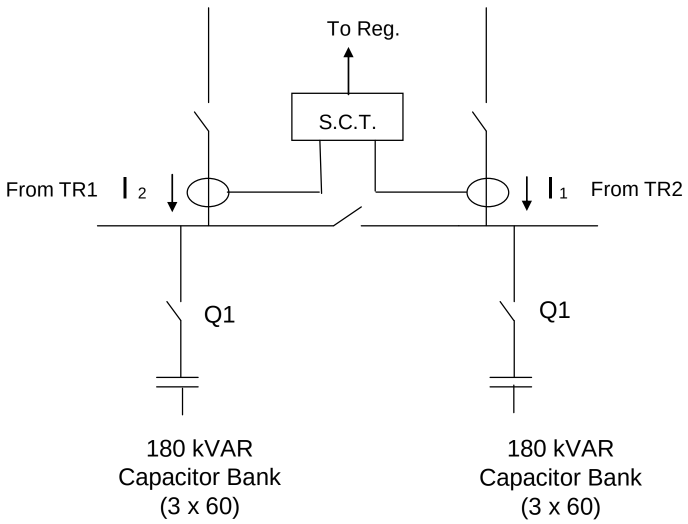


QENA WATER COMPANY	MV 400 kVAR CAPACITOR BANK		*Sponsored By:* GTZ
	Date	01/03/2010	RODECO CONSULTING GMBH
	Drawn By	Marwa	
AL-SALHYA WT PLANT - "Al-Sheikh Husein" Intake	Checked By	A.K.	*Consultant:*
	Approved By		Dr. Ahmed Khozam
	Figure	A4	

CAPACITOR BANKS INSTALLATION DRAWINGS
(Deshna)

APPENDIX A1

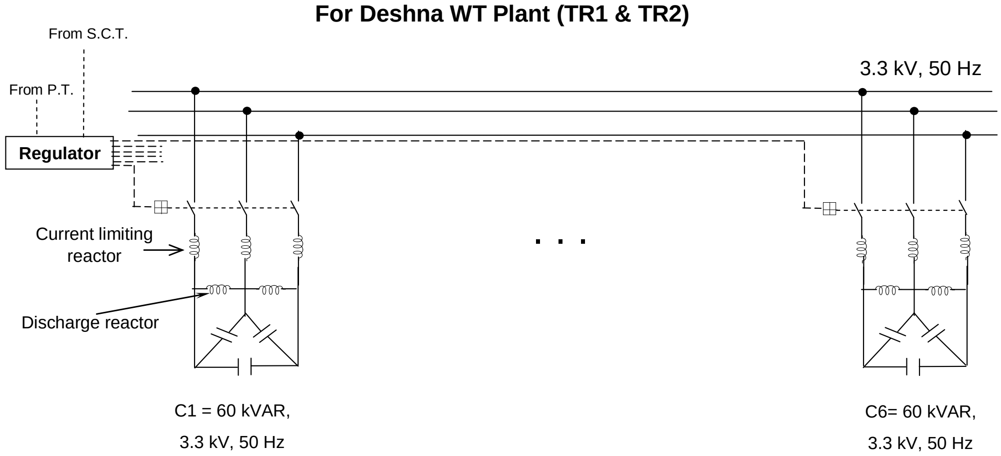
Configuration of 360 kVAR, 3.3 kV, 50 Hz Capacitor Bank for Deshna WT Plant (TR1 & TR2)



QENA WATER COMPANY	**MV 360 kVAR CAPACITOR BANK**		*Sponsored By:*
			GTZ
	Date	01/03/2010	**RODECO CONSULTING GMBH**
	Drawn By	Marwa	
DESHNA WT PLANT	Checked By	A.K.	*Consultant:*
	Approved By		**Dr. Ahmed Khozam**
	Figure	A1	

APPENDIX A2

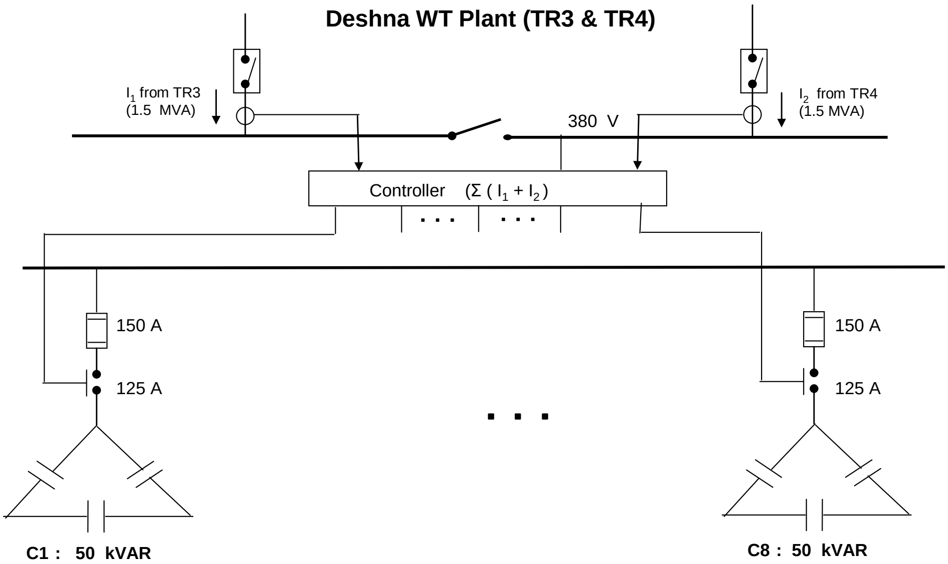
Medium Voltage 360 kVAR Capacitor Bank For Deshna WT Plant (TR1 & TR2)



QENA WATER COMPANY	**360 kVAR, 3.3 kV, 50 Hz CAPACITOR BANK**		*Sponsored By:*
			GTZ
	Date	01/03/2010	**RODECO CONSULTING GMBH**
	Drawn By	Marwa	
DESHNA WT PLANT	Checked By	A.K.	*Consultant:*
	Approved By		**Dr. Ahmed Khozam**
	Figure	A2	

APPENDIX A3

Low Voltage 400 kVAR Capacitor Bank for Deshna WT Plant (TR3 & TR4)

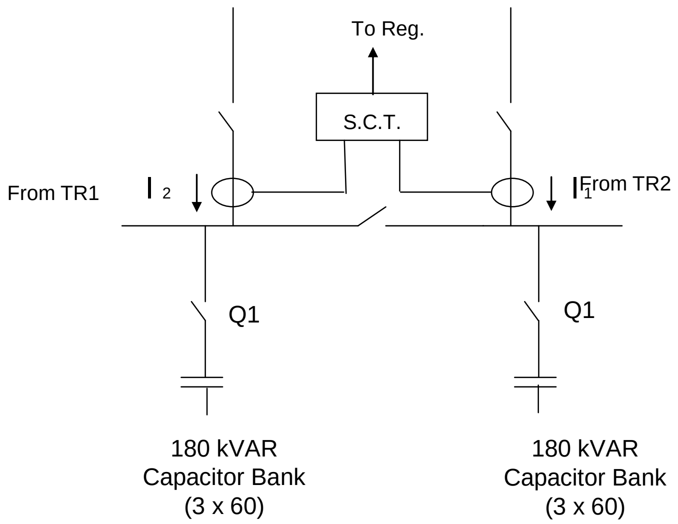


QENA WATER COMPANY	**LV 400 kVAR CAPACITOR BANK (TR5 & TR6)**		*Sponsored By:*
			GTZ
	Date	01/03/2010	**RODECO CONSULTING GMBH**
	Drawn By	Marwa	
DESHNA WT PLANT	Checked By	A.K.	*Consultant:*
	Approved By		**Dr. Ahmed Khozam**
	Figure	A4	

CAPACITOR BANKS INSTALLATION DRAWINGS
(Nag Hammady)

APPENDIX A1

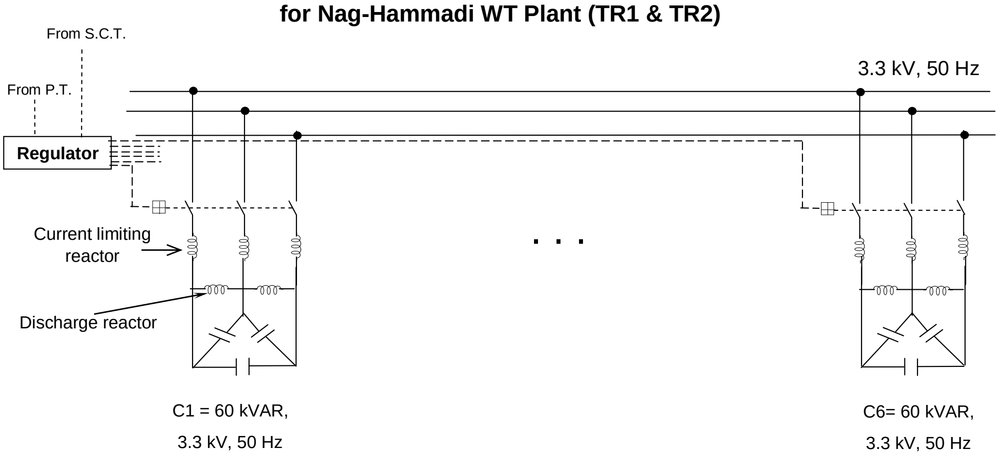
Configuration of 360 kVAR, 3.3 kV, 50 Hz Capacitor Bank for Nag-Hammadi WT Plant



QENA WATER COMPANY	**MV 360 kVAR CAPACITOR BANK**		*Sponsored By:*
			GTZ
	Date	01/03/2010	**RODECO CONSULTING GMBH**
	Drawn By	Marwa	
NAG-HAMMADI WT PLANT	Checked By	A.K.	*Consultant:*
	Approved By		**Dr. Ahmed Khozam**
	Figure	A1	

APPENDIX A2

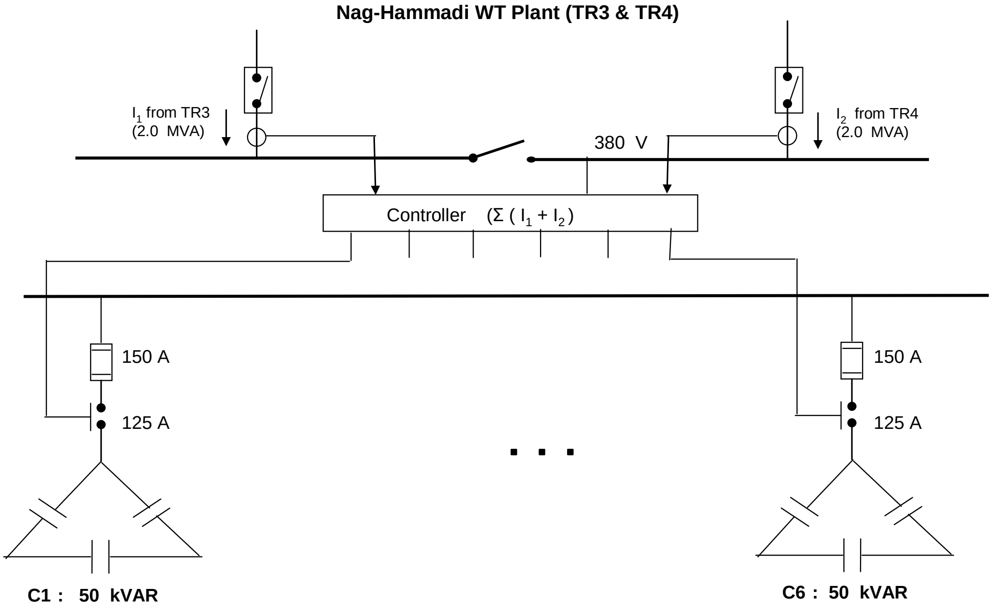
Medium Voltage 360 kVAR Capacitor Bank for Nag-Hammadi WT Plant (TR1 & TR2)



QENA WATER COMPANY	**360 kVAR, 3.3 kV, 50 Hz CAPACITOR BANK**		*Sponsored By:*
			GTZ
	Date	01/03/2010	**RODECO CONSULTING GMBH**
	Drawn By	Marwa	
NAG-HAMMADI WT PLANT	Checked By	A.K.	*Consultant:*
	Approved By		**Dr. Ahmed Khozam**
	Figure	A2	

APPENDIX A3

Low Voltage 300 kVAR Capacitor Bank for Nag-Hammadi WT Plant (TR3 & TR4)

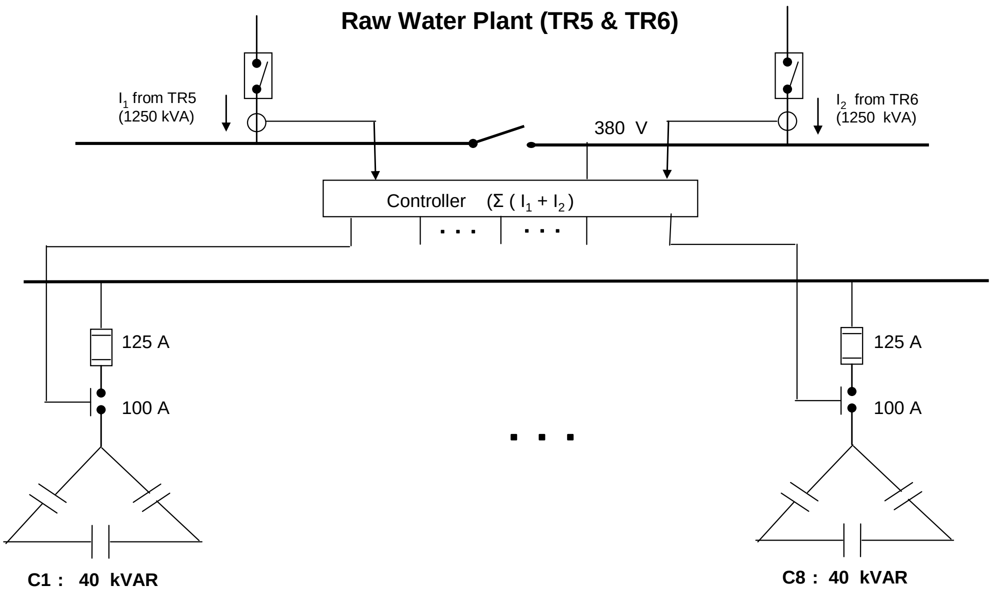


QENA WATER COMPANY	**LV 300 kVAR CAPACITOR BANK**		*Sponsored By:*
			GTZ
	Date	01/03/2010	**RODECO CONSULTING GMBH**
	Drawn By	Marwa	
NAG-HAMMADI WT PLANT	Checked By	A.K.	*Consultant:*
	Approved By		**Dr. Ahmed Khozam**
	Figure	A3	

APPENDIX A4

Low Voltage 320 kVAR Capacitor Bank for

Raw Water Plant (TR5 & TR6)



QENA WATER COMPANY	**LV 320 kVAR CAPACITOR BANK For TR5 & TR6**		*Sponsored By:*
			GTZ
	Date	01/03/2010	**RODECO CONSULTING GMBH**
	Drawn By	Marwa	
NAG-HAMMADI WT PLANT - RAW WATER TRANSFORMERS (TR5 & TR6)	Checked By	A.K.	*Consultant:*
	Approved By		**Dr. Ahmed Khozam**
	Figure	A4	

APPENDIX B

BILLS OF QUANTITIES
AND
EQUIPMENT SPECIFICATIONS

1. BILL OF QUANTITIES – Al Salheya WTP & Intake

The following are the required bills of quantities for the compensating scheme to be installed at Al-Salhya Water Treatment Plant and "Al-Sheikh Husein" Intake. The different system components should comply with the specifications given.

A- For Al-Salhya WT Plant:

Table 1 – 400 kVAR (4 x 100) MV Capacitor Bank

Item No.	Description of work	Qty	Unit price (LE)	Total price (LE)
1	400 kVAR, 3.3 kV, 50 Hz, rack mounted capacitor bank, consisting of four steps, 100 kVAR each. Each step is delta connected, according to specifications and as shown in Appendix A1 and A2. The item should include the following: a - The current limiting reactors for each capacitor bank, b – The discharge reactors, c - Capacitor elements, d - Unbalance tripping and indication alarm devices and accessories.	1		
2	Three phase MV, metal enclosed, manually and motor operated, draw out type vacuum circuit breakers, 3.3 kV, rated current 400 A, short circuit current 25 kA, and complete with its cubicle. The control circuit is operated at 110 V ac.	2		
3	Three phase MV, metal enclosed, manually and motor operated, vacuum circuit breaker, contactor, rated 100 kVAR, for switching the capacitors.	4		
4	Power factor regulator to detect and control the amount of kVARs required for each bus section.	1		
5	Cables and wiring of control circuits	L.S.		
	Total in L.E.			

Table 2 – 360 kVAR (6 x 60) LV Capacitor Bank

	Description of work	Qty	Unit price (LE)	Total price (LE)
1	360 kVAR, 400V, 50 Hz, capacitor bank with controlling equipment as shown in Appendix A3. The item should include the following: a - A panel made of hot enameled steel, floor mounted with hinged doors (enclosure IP 42), b – Three – phase main circuit breakers, air or MCCB type, with rating 800 A/65 kA, c - Copper bus bars with cross section not less than 1.5 A/mm^2 d - 6 (six) groups of H.R.F. of rating 200 A, 600 V complete with fuse holder, e – 6 (six) contactors of rating 150 A at A3 (or 60 kVAR rating), f – 6 (six) 50 kVAR capacitors, 400 V, 50 Hz, g – Power factor regulator 6 stages, h – Power factor meter with digital display, The price should include all necessary connecting cables and accessories.	1		
	Total in L.E.			

B- **For "Al-Sheikh Husein" Intake:**

Table 3 – 400 kVAR (8 x 50) LV Capacitor Bank

	Description of work	Qty	Unit price (LE)	Total price (LE)
2	400 kVAR, 400V, 50 Hz, capacitor bank with controlling equipment as shown in Appendix A4. The bank will be used to improve the power factor at the outgoing bus bars of either TR5 or TR6. The item should include the following: a - A panel made of hot enameled steel, floor mounted with hinged doors (enclosure IP 42), b – Three – phase main circuit breaker, air or MCCB type, with rating 1250 A/65 kA, c - Copper bus bars with cross section not less than 1.5 A/mm2 d - 8 (eight) groups of H.R.F. of rating 150 A, 600 V complete with fuse holder, e – 8 (eight) contactors of rating 125 A at A3 (or 50 kVAR rating), f – 8 (eight) 50 kVAR capacitors, 400 V, 50 Hz, g – Power factor regulator 12 stages, h – Power factor meter with digital display, The price should include all necessary connecting cables and accessories.	1		
	Total in L.E.			

2. BILL OF QUANTITIES – Deshna WTP

The following are the required bill of quantities for the compensating scheme to be installed. The different system components should comply with the specifications given.

Table 1 – 360 kVAR (6 x 60) MV Capacitor Bank
For TR1 and TR2

Item No.	Description of work	Qty	Unit price (LE)	Total price (LE)
1	360 kVAR, 3.3 kV, 50 Hz, rack mounted capacitor bank, consisting of four steps, 100 kVAR each. Each step is delta connected, according to specifications and as shown in Appendix A1 and A2. The item should include the following: a - The current limiting reactors for each capacitor bank, b – The discharge reactors, c - Capacitor elements, d - Unbalance tripping and indication alarm devices and accessories.	1		
2	Three phase MV, metal enclosed, manually and motor operated, draw out type vacuum circuit breakers, 3.3 kV, rated current 400 A, short circuit current 25 kA, and complete with its cubicle. The control circuit is operated at 110 V ac.	2		
3	Three phase MV, metal enclosed, manually and motor operated, vacuum circuit breaker, contactor, rated 60 kVAR, for switching the capacitors.	6		
4	Power factor regulator to detect and control the amount of kVARs required for each bus section.	1		
5	Cables and wiring of control circuits	L.S.		
	Total in L.E.			

Table 2 – 400 kVAR (8 x 50) LV Capacitor Bank
For TR3 and TR4

	Description of work	Qty	Unit price (LE)	Total price (LE)
2	400 kVAR, 400V, 50 Hz, capacitor bank with controlling equipment as shown in Appendix A3. The bank will be used to improve the power factor at the outgoing bus bars of either TR3 or TR4 or both. The item should include the following: a - A panel made of hot enameled steel, floor mounted with hinged doors (enclosure IP 42), b – 2 (Two) three – phase main circuit breaker, air or MCCB type, with rating 600 A/65 kA, c - Copper bus bars with cross section not less than 1.5 A/mm^2 d - 8 (eight) groups of H.R.F. of rating 150 A, 600 V complete with fuse holder, e – 8 (eight) contactors of rating 125 A at A3 (or 50 kVAR rating), f – 8 (eight) 50 kVAR capacitors, 400 V, 50 Hz, g – Power factor regulator 12 stages, h – Power factor meter with digital display, The price should include all necessary connecting cables and accessories.	1		
	Total in L.E.			

3. BILL OF QUANTITIES – Nag Hammady

The following are the required bill of quantities for the compensating scheme to be installed at Nag-Hammadi Water Treatment Plant. The different system components should comply with the specifications given.

Table 1 – 360 kVAR (6 x 60) MV Capacitor Bank

Item No.	Description of work	Qty	Unit price (LE)	Total price (LE)
1	360 kVAR, 3.3 kV, 50 Hz, rack mounted capacitor bank, consisting of four steps, 100 kVAR each. Each step is delta connected, according to specifications and as shown in Appendix A1 and A2. The item should include the following: a - The current limiting reactors for each capacitor bank, b – The discharge reactors, c - Capacitor elements, d - Unbalance tripping and indication alarm devices and accessories.	1		
2	Three phase MV, metal enclosed, manually and motor operated, draw out type vacuum circuit breakers, 3.3 kV, rated current 400 A, short circuit current 25 kA, and complete with its cubicle. The control circuit is operated at 110 V ac.	2		
3	Three phase MV, metal enclosed, manually and motor operated, vacuum circuit breaker, contactor, rated 60 kVAR, for switching the capacitors.	6		
4	Power factor regulator to detect and control the amount of kVARs required for each bus section.	1		
5	Cables and wiring of control circuits	L.S.		
	Total in L.E.			

Table 2 – 300 kVAR (6 x 50) LV Capacitor Bank for TR3 and TR4

	Description of work	Qty	Unit price (LE)	Total price (LE)
1	300 kVAR, 400V, 50 Hz, capacitor bank with controlling equipment as shown in Appendix A3. The item should include the following: a - A panel made of hot enameled steel, floor mounted with hinged doors (enclosure IP 42), b – 2 (two) three – phase main circuit breaker, air or MCCB type, with rating 400 A/65 kA, c - Copper bus bars with cross section not less than 1.5 A/mm^2 d - 6 (six) groups of H.R.F. of rating 150 A, 600 V complete with fuse holder, e – 6 (six) contactors of rating 125 A at A3 (or 50 kVAR rating), f – 6 (six) 50 kVAR capacitors, 400 V, 50 Hz, g – Power factor regulator 6 stages, h – Power factor meter with digital display, The price should include all necessary connecting cables and accessories.	1		
	Total in L.E.			

Table 3 – 320 kVAR (8 x 40) LV Capacitor Bank for TR5 and TR6

2	320 kVAR, 400V, 50 Hz, capacitor bank with controlling equipment as shown in Appendix A4. The bank will be used to improve the power factor at the outgoing bus bars of either TR5 or TR6. The item should include the following: a - A panel made of hot enameled steel, floor mounted with hinged doors (enclosure IP 42), b – 2 (two) three – phase main circuit breaker, air or MCCB type, with rating 400 A/65 kA, c - Copper bus bars with cross section not less than 1.5 A/mm^2 d - 8 (eight) groups of H.R.F. of rating 125 A, 600 V complete with fuse holder, e – 8 (eight) contactors of rating 100 A at A3 (or 50 kVAR rating), f – 8 (eight) 40 kVAR capacitors, 400 V, 50 Hz, g – Power factor regulator 12 stages, h – Power factor meter with digital display, The price should include all necessary connecting cables and accessories.	1		
	Total in L.E.			

4. SYSTEM REQUIREMENTS AND TECHNICAL PECIFICATIONS

General Specifications of Capacitor Banks

It is required to supply, install, commission and hand over in a perfect working conditions 3 (three) complete systems of switched steps capacitor banks. The required systems, as stated before, should consist of the following elements:

- Medium voltage switched capacitor banks (one)
- Low Voltage switched capacitor banks (two)
- Power factor regulators.
- Medium voltage metal enclosed draw out type motor operated MV, circuit breaker or MV contactor.

a) ***<u>MV automatically regulated switched capacitor banks</u>***:

The configuration of each capacitor bank should be as indicated in the attached figures and consist of the following:

- Metal clad cubicle panel: indoor type, floor mounted assembly, provided by suitable ventilation method, to maintain thermal stability. The cubicles shall be designed to accommodate different equipment with reserve for future extension of capacitor units. All the instruments shall be mounted on a hinged door at the front of the cubicle. Micro switch shall be provided to cubicle door for safety operation.
- The vacuum contactors which are used for switchable capacitor banks must have a good switching capability up to the highest bank rating without restrike and thus without over-voltage occurring. The selected contactors should be suitable to operate automatically according to signal from PF controller and must withstand voltage and current stresses expected during operation.
- Capacitor elements having specifications as given below.
- Electronic PF Regulator including all associated equipment. The controller should be fitted with automatic no-voltage release feature, which disconnects all capacitors in case of a main failure. When the main voltage returns, the controller commences operation after reasonable time delay. The controller should be equipped by a means for allowing manual operation. Test buttons shall be provided. A time delay shall exist between switching off each stage, so as to allow for capacitor discharge time.
- Current limiting reactors
- Discharge reactors.
- Switch gear with the proper type and medium should comply with the following characteristics:
  1. It should withstand the transient inrush currents at switching on.
  2. It should have adequate braking capacity at least as high as the system fault current at the point of connection of the bank.
  3. It should protect the capacitors effectively against permanent over-voltages and over-currents.
- Unbalance current protection, for star configuration.

- Over voltage protection (to prevent the voltage on each capacitor to exceed its safe operating voltage 1.1 V_n).
- Indication alarm devices.
- The panel should be constructed to ensure human safety. All normally energized parts should be insulated to provide adequate protection to operating persons.

b) ***<u>LV automatically switched capacitor banks</u>*****:**

The configuration of the low voltage capacitor banks is given in Appendix 3 and 4 for Al-Salhya WT plant and "Al-Sheikh Husein" Intake. Each bank should include, but is not limited to, the following elements:

- Capacitors elements, having specifications as given below, should be factory assembled and wired in dust tight metal enclosures with a backed enamel finish. Integral mounting brackets should be provided to facilitate wall or floor mounting.
- A door-mounted, microprocessor-based, multi-step, adjustable power factor controller. The controller shall be provided with the following:
  - ❖ A manual or automatic selector switch.
  - ❖ Adjustable switching time delay from 10 to 60 seconds.
  - ❖ Digital display of actual power factor.
  - ❖ Continuous front panel display indicating which steps are on.
  - ❖ Rotational switching sequence to ensure that the steps are used equally.
  - ❖ Operating temperature range from - 10^o C to 55^o C .
- Current limiting fuses shall be provided on all three phases of each step.
- The individual capacitor steps shall be switched using a contactor suitable for switching capacitor currents. The minimum life expectancy of the contactor shall be not less than one million switching operations.
- Over voltage protection (to prevent the voltage on each capacitor to exceed its safe operating voltage 1.1 V_n).
- All internal buswork shall be bare tin plated copper, or insulated copper conductor.
- The main circuit breaker of the capacitor bank must comply with the standard specifications, provided with high interrupting capacity and solid state trip mechanism. The incoming power cable connections should be appropriately sized for the breaker.
- All flexible power cable shall be copper conductor, 105^o C insulation, installed in accordance with the latest revision of the IEC.

Capacitor Specifications

1. Capacitors must comply with the IEC standards and, at least, one of the following standards:
   - C 54-100 (French)
   - NEMA Cp 1 (American)
   - BS 1650 (British)
   - VDE 0560 (German)

<u>The Following is Applied Only for Medium Voltage Capacitors:</u>

2. Capacitors should be of ***dry*** type, enclosed in steel tanks with two porcelain insulators. The tank comprises the assembly of the capacitor elements. The dielectric used in the capacitor should be of the non-hydrocarbon and polypropylene film, i.e. all plastic film or equivalent. Nameplates should be attached to enclosures giving name of manufacturer, rated voltage, kVAR rating and number of poles.

3. **<u>Insulation Level</u>**

The insulation level of the units should be equivalent to that of the bank, otherwise extra insulation to the units is necessary. The insulation level should not be less than 3.5 cm/kV.

- The withstand test voltage (r.m.s) at a.c power frequency should be 60 kV for 3.3 kV capacitor bank.
- The withstand impulse test voltage crest value should be 20 kV for 3.3 kV capacitor bank 20 kV

<u>The Following is Applied Only for Low Voltage Capacitors:</u>

4. LV individual capacitors should be factory assembled in the metal enclosures and wired in a 3-phase, 420 V, configuration with termination provisions within the enclosure to facilitate field connection to system wiring.

5. Each capacitor unit should contain discharge resistors to bleed off residual voltage after power is removed from the unit. For the low voltage capacitors, discharge should be to a residual voltage of 50 V or less in 5 min.

6. The value of the capacitance should lie between 95% and 110% of the nominal value.

7. The capacitors should be with self-healing, and extra reduced losses (less than 0.5 W / kVAR) including the losses of the discharge resistance.

8. Capacitors should be well adapted to automatic step systems controlled by power factor regulators.

9. Capacitance variation in relation to temperature should be less than 4^oC over the ambient temperature range 20^o to 50^o C.

10. Each capacitor cell should be furnished with a built-in pressure sensitive interrupter recognized by the UL-recommendations.

Voltage and Overload Specifications:

- Insulation level of capacitors : ≥ 0.6 kV
- Operating over-voltage at the capacitor terminals : 10% over long periods
- Temporary over-voltage (5 min.) : 20 kV
- Impulse voltage test (1.2/50 µs.) : 15 kV
- Over current due to harmonics : 30 %

Protection:

- Capacitors should be fused with current limiting replacable fuses. Fuses should be factory installed in enclosures.
- Capacitors should have blown fuse indicator lamps. Lamps should provide for quick external inspection for blown fuses.
- Capacitors should be provided by modular cable entry boxes (IP45).

Temperature Class:

- From -10^o C to 50^o C under the ambient air temperature.
- Maximum temperature : 50^o C
- Average temperature over 24 hours : 40^o C
- Average temperature over one year : 30^o C

Switching Devices:

Switching devices are to be rated for at least 135 percent of the continuous current rating for the system circuit capacity.

Accessories:

Any accessories not mentioned in the specifications and required for satisfactory and proper operation shall be offered by the tenderer.

Tests:

Tests for capacitors and accessories shall be carried out in accordance to the latest IEC specifications. The tests specified for capacitors shall be of two kinds: routine tests and type tests (IEC 871-1) (1987). Routine tests shall be carried out on every capacitor on completion. Type tests are intended to prove the soundness of the design of the capacitor and its suitability for operation under the actual site conditions.

APPENDIX C

ELECTRICITY TARIFFS

Electricity Tariff for Water and Wastewater Utilities (2008/2009)

1. **<u>Energy Charge:</u>**

   LE 0.214 / kWh

2. **<u>Demand Charge:</u>**

   LE 9.5 / kW – month

3. **<u>Power Factor:</u>**

Power factor penalty as levied by all utilities in Egypt are calculated as follows:

- For average PF $\geq$ 0.7 and < 0.9 :

Penalty = 0.5 * (0.9 – pf) * Energy cost / yr

- For average pf < 0.7 (3 months):

Penalty = 1.0 * (0.7 – pf) * Energy cost / yr

- For average pf < 0.7 (7 months):

Penalty = 2.0 * (0.7 – pf) * Energy cost / yr

Power factor bonus is offered for PF higher than 0.92 and less than 0.95. Higher than 0.95 no bonus is offered; thus bonus is calculated as follows:

Bonus = 0.5 * (pf – 0.92) * Energy cost /yr

Billing system for both penalty and bonus is applied on annual basis.

محطة مياه الصالحية

تقرير فني عن كيفيه فصل الكهرباء عن محولات الضغط العالي بمحطة مياه الصالحية

مخطط عن لوحات الكهرباء للطلمبات والمحولات

أولا : لوحه تشغيل الطلمبات kv 3.3

طلمبة رقم 1 Pump 1	طلمبة رقم3 pump3	طلمبة رقم5 Pump5	مغذي 1 Line 1	الرابط Bus coupler	مغذي 2 Line 2	طلمبة رقم2 Pump2	طلمبة رقم4 Pump4	طلمبة رقم6 Pump6

الحالات التي يمكن تعشيق اللوحة بها

محول 1 Line 1	محول 2 Line 2	الرابط Bus coupler
1	1	0
1	0	1
0	1	1

0 وضع الفصل off 1 وضع التشغيل on

ثانيا : لوحه الجهد المتوسط 11 KV

تغذيه محول4 T4(11/0.4KV) 2MVA	تغذيه محول T2(11/3.3KV) 2 2.5 MVA	الديزل D.G.S	مغذي الصالحية2 LINE 2 11KV	الرابط Bus coupler	مغذي الصالحية 1 LINE 1 11KV	الديزل D.G.S	تغذيه محول3 T3(11/0.4KV) 2MVA	تغذيه محول 1 T1(11/3.3KV) 2.5 MVA

الحالات التي يمكن تعشيق اللوحة بها

المولد D.G.S	الرابط Bus coupler	الصالحية 2 LINE 2 11KV	الصالحية 1 LINE 1 11KV
0	0	1	1
0	1	0	1
0	1	1	0
1	1	0	0
1	0	0	0

0 وضع الفصل off   1 وضع التشغيل on

ثالثا :لوحه الجهد المخفض 0.4 KV (RH 1:1 S.D)

أوضاع التشغيل في لوحه الجهد المنخفض

مغذي رقم 1 LINE 1 0.4KV
الرابط coupler
مغذي رقم 2 LINE 2 0.4KV

طرق التعشيق علي لوحه الجهد المنخفض

إلي لوحه التحكم في الطلمبات (لوحه تشغيل الطلمبات)

الرابط Coupler	مغذى (2) LINE 2 0.4KV	مغذى (1) LINE 1 0.4KV
0	1	1
1	0	1
1	1	0

الطرق التي المتبعة لفصل المحطة:

أولا:- لفصل الصالحية واحد

1 - يتم فصل الطلمبات رقم 1 ، 3 ، 5 من علي لوحه الجهد 3.3 kv

2 - يتم فصل محول 1 ، 3 من علي لوحه الجهد 11 kv

3 - يتم فصل خط الصالحية 1 من علي لوحه الجهد 11 kv

4 - التأكد ان الرابط مفصول

وبذلك يكون محول 1 ، 3 ليس عليهم جهد

ثانيا : لفصل الصالحية 2

5 - يتم فصل الطلمبات رقم 2 ، 4 ، 6 من علي لوحه الجهد 3.3 kv

6 - يتم فصل محول 2 ، 4 من علي لوحه الجهد 11 kv

7 - يتم فصل خط الصالحية 2 من علي لوحه الجهد 11 kv

8 - التأكد ان الرابط مفصول

وبذلك يكون محول 2 ، 4 ليس عليهم جهد

مع ملاحظه ان في هذه الحالة سوف يتم فصل جميع الطلمبات للمحطة لان كنترول اللوحات علي محول رقم رقم 4

ولكي يتم تعشيق المحطة مره أخري :

يتم إتباع نفس الخطوات السابقة ولكن بطريقه عكسية أي نبدأ بأخر خطوه ثم ننتهي بأول خطوه بدأنا بها

عنبر طلمبات المياه المرشحة

التوصيف
م1 الى م6 طلمبات مرشحات
ل1 الى ل6 لوحة كهرباء
ح كل1 الى ح كل4 حقن كلور
تح1 الى تح2 طلمبات تحضير
ج تصرف
ق منسوب
ق ض رئيسى
ونش
ط غ1 – ط غ2 طلمبة غاطسة
ط ع1 – ط ع2 طلمبة عينات

عنبر الشبة

التوصيف	العدد
ح ش1 الى ح ش3 أحواض الشبة	3
ط ش1 الى ط ش4 طلمبات الشبة	4
خ1 الى خ6 خلاطات	6
ميزان ميزان	1
ونش	1

عنبر الكلور

التوصيف	العدد
خط الكلور	2
ميزان	2
طلمبات الصودا	2
بلاور	2
شفاطات	6
المبخرات	2
أجهزة حقن الكلور	4
أجهزة قياس الكلور النهائي	2
جهاز إنذار عند تسريب الكلور	1
ونش	1

عنبر المرشحات

التوصيف	العدد
أحواض مرشحة المرحلة الأولى	8
أحواض مرشحة المرحلة الثانية	6
طلمبات الغسيل	2
الفنشورى	9

بلاور	2
كمبرسور	3
طلمبات العينة	8
طلمبات التحضير	2
جهاز قياس الكلور	1
أجهزة قياس المنسوب	4
ونش	1
طلمبات الغاطسة	2
نظام الهيدروفورم	1

عنبر الروية

التوصيف	العدد
طلمبات الروية	2
طلمبات الغاطسة	2
أجهزة قياس المنسوب	2
أحواض الروية	2

المروقات

التوصيف	العدد
حوض مروق	4
كساحات	4
خلاطات	4

بئر التوزيع

التوصيف	العدد
أجهزة قياس المنسوب	1

المحابس داخل المحطة

المحابس الكهرباء	12
المحابس اليدوي	10

APPENDIX E

TRAINING DOCUMENTATION
(LIST OF ATTENDEES & TRAINING MATERIAL)

List of QCWW Attendees

Earthing, Design, Installation & Testing

Kenouz Training Center

1	Amr Ahmed Mohamed
2	Ahmed Fawzy Ali
3	Zenab Amr Mohamed
4	Nageb Wadea Agaby
5	Ali Ahned Awasee
6	Asma Mohamed Ahmed
7	Shaema Hassan
8	Maysara Abdeen
9	Shaema Ahmed Dahy
10	Ahmed Mohamed Alwa
11	Lila Saed Elkady
12	Nabila Rafat Younan
13	Hamdy Fouad Abdella
14	Housam Mohmaed
15	Mahmud Mohamed
16	Mohamed Ali Mohamed
17	Mohmaed Hassan
18	Mustafa Mohamed
19	Mohamed Saed
20	Mohamed Hamam
21	Saeed Mohamed
22	Ahmed Hagagy
23	Saed Abdelkirim
24	Ali Mahmud Ali

ENERGY EFFICIENCY IMPROVEMENT & BENCHMARKING FOR WATER TREATMENT PLANTS

Dr. Ahmed Khozam

GEF UNDP Energy Efficiency Improvement in Egypt

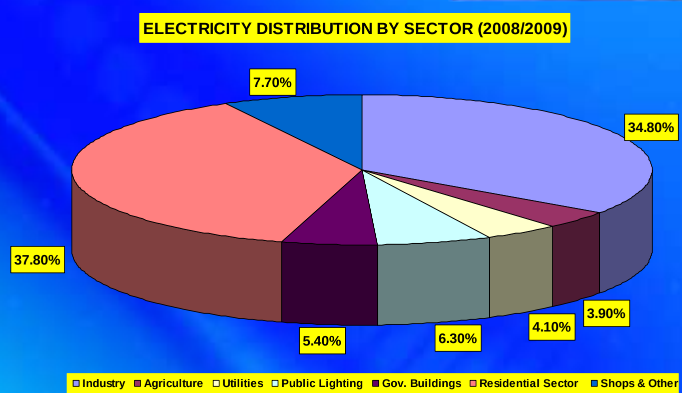
TOPICS TO BE COVERED:

1. What is Energy Efficiency & Why it is Important?
2. Water Cycle and Water Treatment Plants
3. The Concept of Benchmarking.
4. Large Water Treatment Plants in Egypt.
5. *Performance Evaluation & Comparison with Best Practices.*
6. *EE Measured in WT & WWT Plants.*
7. Conclusions & Recommendations

What is Energy Efficiency & Why it is Important?

- Energy efficiency improving is the process of minimizing energy use without affecting the quality of service or product.
- In Water and Wastewater Treatment plants improvement in energy efficiency from 20 to 30% could be achieved.
- Energy Cost in WT and WWT Plants represent approximately 30 – 50% of total cost of the production of 1 m^3.
- On the national level:

FINAL ENERGY CONSUMPTION (Total = 112617 GWh)



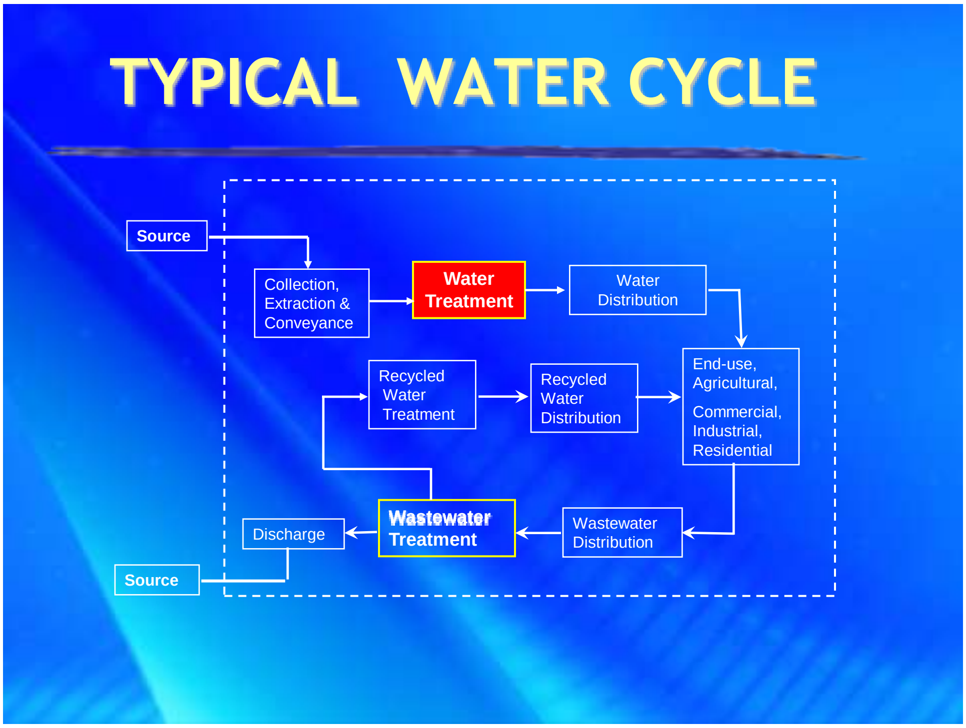
Utilities Consumption (4.1%) = 4617 GWh

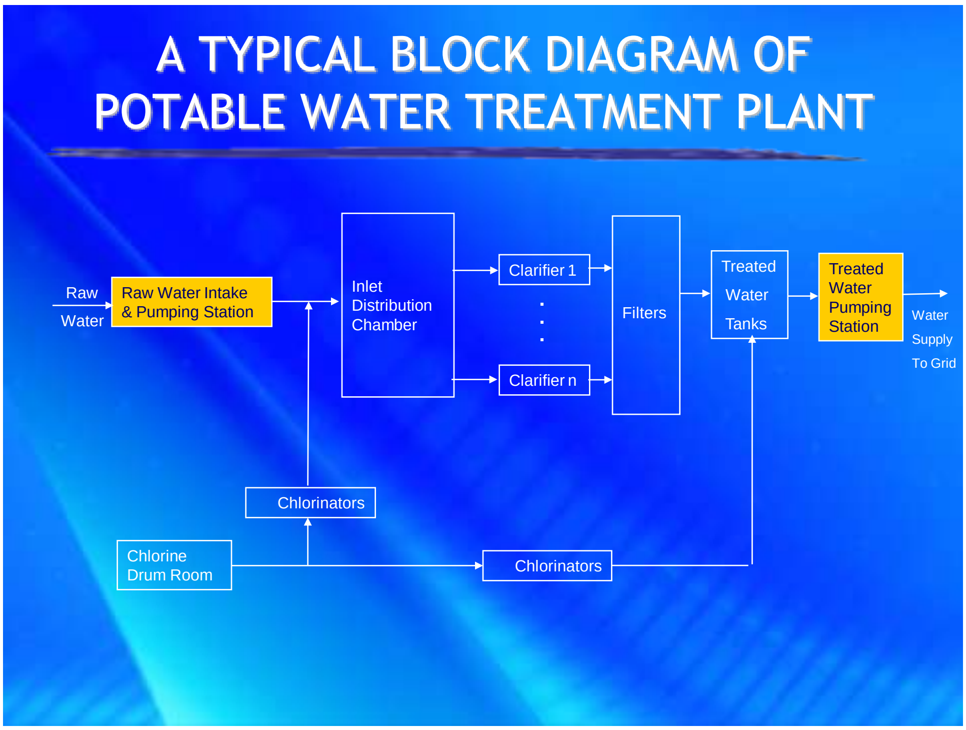
ELECTRICITY CONSUMPTION in WT & WWT PLANTS

1. All Utilities in Egypt consume 4.1% of total electricity consumption.
2. The share of Water and Wastewater Plants represent ≈ 3% of total consumption (of cost > LE 800 million)
3. The 12 Cairo Water Plants consume more than 860000 MWh / year (i.e. 20% of total Utilities consumption)
4. Wastewater plants in Egypt consume ≈ 150 000 MWh / year.

KEY QUESTIONS FOR ENERGY EFFICIENCY IMPROVEMENT

- *What are the most energy intensive facilities in the WATER CYCLE?*
- *HOW to evaluate the PERFORMANCE of these facilities?*
- *What is the CRITERIA for evaluating the performance?*
- *Is any POTENTIAL FOR ENERGY EFFICIENCY IMPROVEMENY in these facilities?*
- *What is the proposed ACTION PLAN?*


TYPICAL WATER CYCLE
Source
Collection, Extraction & Conveyance
Water Treatment
Water Distribution
End-use, Agricultural, Commercial, Industrial, Residential
Recycled Water Treatment
Recycled Water Distribution
Wastewater Distribution
Wastewater Treatment
Discharge
Source


A TYPICAL BLOCK DIAGRAM OF POTABLE WATER TREATMENT PLANT
Raw Water
Raw Water Intake & Pumping Station
Inlet Distribution Chamber
Clarifier 1
Clarifier n
Filters
Treated Water Tanks
Treated Water Pumping Station
Water Supply To Grid
Chlorinators
Chlorine Drum Room
Chlorinators

HIGH ENERGY CONSUMING POTENTIAL FACILITIES & COMPONENTS

- *Water Treatment & Wastewater Treatment Plants are the Most Energy Consuming Facilities in the WCM System.*
- *WT & WWT Facilities Consume more than 80% of Total Energy Consumption in the WC*
- *In any Water Treatment Plant, the Most Energy Consuming Departments are:*
    - *Treated Water Plant*
    - *Raw Water Plant*
- *In Wastewater Treatment, AERATION Process is the most Energy Consuming Process*

TYPICAL APPROACH FOR ENERGY EFFICIENCY IMPROVEMENT

Data Collection

↓

Benchmarking

↓

Site Visits & Short Audits

↓

Identify Energy Efficiency Opportunities

↓

TYPICAL APPROACH FOR EE IMPROVEMENT(Cont.)

⇩

Conduct a Pre-feasibility Study

⇩

Detailed Design & Plan of Implementation

⇩

Implementation, Commissioning & Start-up

⇩

Monitoring & Verification

1. DATA COLLECTION

➢ **Information on WT & WWT Plants to be Covered Including:**

- *Design Production Capacity (m^3)*
- *Actual Production Capacity (m3)*
- *Annual Energy Consumption (kWh)*
- *Power Factor*
- *Peak Demand (kW)*
- *Major Loads, … etc.*

➢ **A "QUESTIONNAIRE" is Designed for this Purpose.**

LOOK FOR UTILITY BILLS:

WHAT ARE THE COSTS OF ENERGY per MONTH & per YEAR?

UTILITY BILL

- ☒ Electricity
- ❑ Natural gas
- ❑ Fuel oil

ELECTRICITY

- **Consumption (kWh)**
- **Max. Demand (kW)**
- **Power Factor**
  (Penalty for PF < 0.9)
- **…. Other**

HOW ELECTRICITY BILL & PF PENELTY IS CALCULATED?

1. Energy Charges:

21.4 Pt/kWh

2. Demand Charges:

9.5 LE/kW-month

3. PF Penalty:

- 0.9 > PF > 0.7 (0.9 – PF) * 0.5 * Energy Cost
- PF < 0.7 for 3 months (0.9 – PF) * 1.0 * Energy Cost
- PF < 0.7 for 6 months (0.9 – PF) * 2 * Energy Cost

BENCHMARKING

Benchmarking is the comparison of a business's current level of performance against a pre-defined point of reference (or benchmark) in order to assess the potential for improving its performance and reduce its energy consumption.

BENCHMARKING CONCEPT

- Companies often think that they are highly energy-efficient
- Benchmarking provides a tool to test this perception
- Benchmarking programs typically result in increased attention to energy efficiency.
- *Most businesses can reduce energy costs by a minimum of 20 - 30% by introducing an energy efficiency programme.*
- Key barrier is lack of information

Energy Benchmarking Process

1. Gain Commitment & Assign Responsibility
2. Analyse Current Performance
3. Benchmarking
   (Compare Performance & Set Targets)
4. Energy Survey
5. Implement Action Plan
6. Monitor & Control

LARGE POTABLE WT PLANTS IN CAIRO

الكود	Production m3/day	محطة المياه
1	158,050	محطة مياه الجيزة
2	1,033,163	محطة مياه إمبابة
3	753,335	محطة مياه روض الفرج
4	380,000	محطة مياه شبرا الخيمة
5	450,000	محطة مياه جزيرة الدهب
6	64,158	محطة مياه كفر العلو
7	441,256	محطة مياه الأميرية
8	110,000	محطة مياه الروضة
9	1,150,000	محطة مياه مسطرد
10	1,111,908	محطة مياه الفسطاط
11	56,890	محطة مياه التبين
12	195,161	محطة مياه شمال حلوان

MAJOR PARAMETERS & PERFORMANCE EVALUATION OF WATER TREATMENT PLANTS IN CAIRO - 2006

Station	Mostorod	Gezirat Al-Dahab	Shobra Al-Kh.	Al-Roda
Design Value of Supply Capacity (m^3/day)	1,150,000	450,000	380,000	110,000
Actual Annual Supply Capacity (000 m^3/year)	400,252,650	186,486,190	124,242,910	65,578,390
Annual Electricity Consumption (kWh/year)	192,864,114	56,129,728	36,719,552	30,789,590
Specific Energy Consumption (kWh/m^3)	**0.482**	**0.301**	**0.296**	**0.470**
Maximum Demand (kW)	9200	9965	4960	2458
Load Factor (%)	*52%*	*49% (79.9%)*	*71%*	*73%*
Power Factor	0.81	0.84	0.8	0.85

MAJOR PARAMETERS & PERFORMANCE EVALUATION OF WATER STATIONS IN CAIRO – 2006 (CONT.)

Station	Al-Giza	Embaba	Rod-Elfarag	Kafr-Elelw
Design Value of Supply Capacity (m^3/day)	158,050	1,033,163	753,335	64,158
Actual Annual Supply Capacity (000 m^3/year)	57,688	377,104	274,967	23,417
Annual Electricity Consumption (kWh/year)	5,677,612	92,181,002	79,911,180	8,550,234
Specific Energy Consumption (kWh/m^3)	**0.157**	**0.244**	**0.291**	**0.365**
Maximum Demand (kW)	2850	n.a	n.a	n.a
Load Factor (%)	23%	n.a	n.a	n.a
Power Factor	0.8	n.a	n.a	n.a

MAJOR PARAMETERS & PERFORMANCE EVALUATION OF WATER STATIONS IN CAIRO (CONT.)

Station	El Fostat	Helwan	Al Tebin	El Ameria
Design Value of Supply Capacity (m^3/day)	1,111,908	195,161	56,890	441,256
Actual Annual Supply Capacity (000 m^3/year)	405,846	71,234	138,700	151,203
Annual Electricity Consumption (kWh/year)	198,054,810	56,417,706	33,466,342	69,709,340
Specific Energy Consumption (kWh/m^3)	0.488	0.792	0.588	0.482
Maximum Demand (kW)	n.a	n.A	n.a	n.a
Load Factor (%)	n.a	n.A	n.a	n.a
Power Factor	n.a	n.a	n.a	n.a

FINDINGS FROM TABLES

LOAD FACTOR (LF) RANGES FROM 49% TO 73%

$$LF = \frac{\text{Average kW Load Over a Billing Period}}{\text{Peak Demand}}$$

Ideal Load Factor = 1

LF Improvement ≡ **Demand Control**

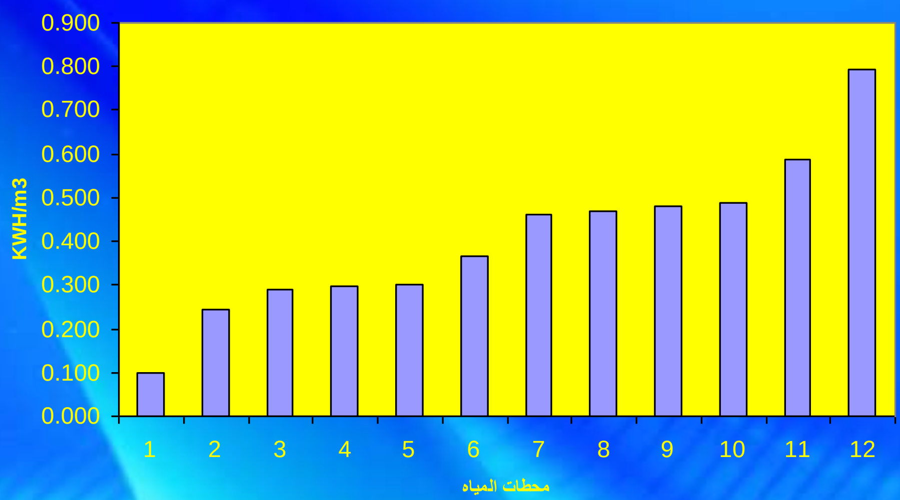
LF Improvement Depends on:

- The Power Profile of the Station
- Availability of Sheddable Loads
- The Rate Schedule (if exists).

Results of Specific Energy Consumption

بداية التشغيل	SEC For Year 2006 kWh/m³	محطة المياه
1898	0.157	محطة مياه الجيزة
1975	0.244	محطة مياه إمبابة
1903	0.291	محطة مياه روض الفرج
1971	0.296	محطة مياه شبرا الخيمة
1973	0.301	محطة مياه جزيرة الدهب
1923	0.365	محطة مياه كفر العلو
1960	0.461	محطة مياه الأميرية
1978	0.470	محطة مياه الروضة
1970	0.482	محطة مياه مسطرد
1989	0.488	محطة مياه الفسطاط
1973	0.588	محطة مياه التبين
1963	0.792	محطة مياه شمال حلوان

Specific Energy Consumption (SEC) for Year 2006



BENCHMARKING COMPARISON OF SEC WITH OTHER COUNTRIES:

Country	SEC (kWh/m³)
Egypt:	
1. Cairo	**0.157 – 0.792**
2. Albehera	**0.187 – 0.351**
3. Qena	**0.27 – 0.82**
Brazil	0.072 – 0.40
Tunis	0.13 – 0.27
Jordon	0.55 – 0.80

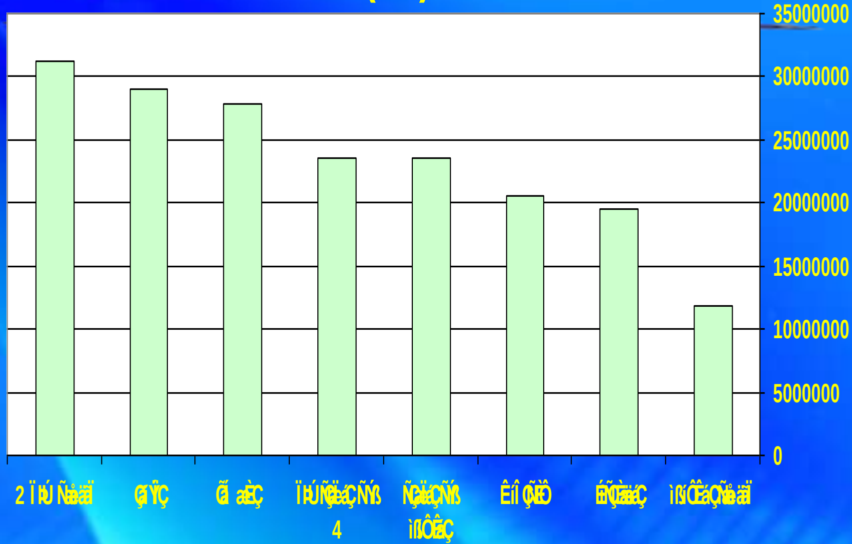
WHY AL-BEHERA TW PLANTS HAVE BETTER PERFORMANCE?:

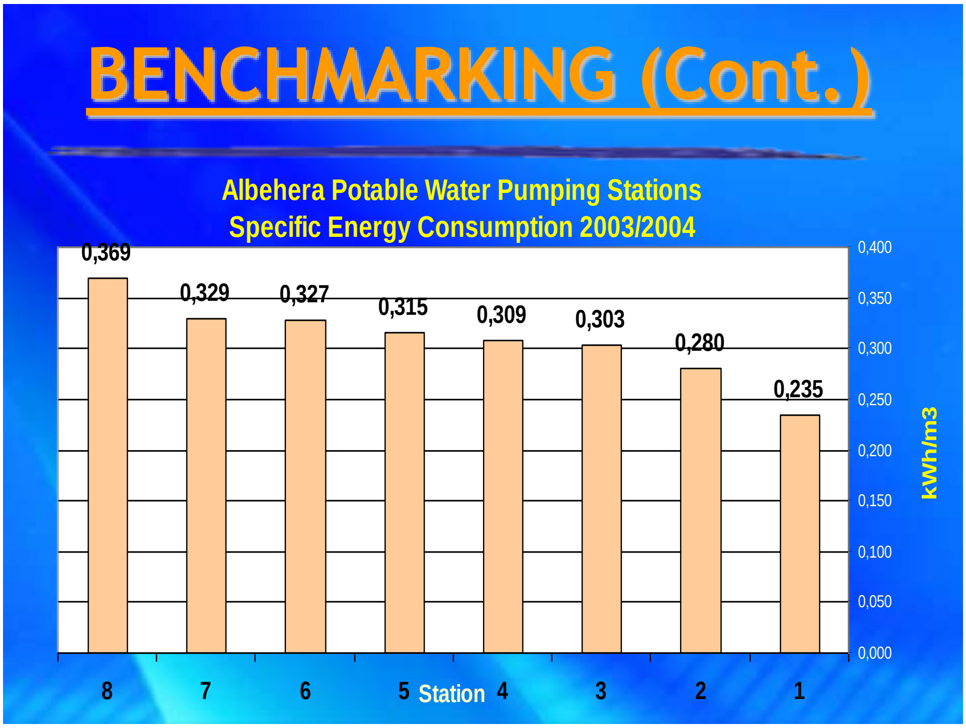
- ❖ **Most of the plants improved PF.**
- ❖ **Some Plants Applied VSD (Damanhour 2).**
- ❖ **Perfect Management & Building of Human Resources.**
- ❖ **Good System of Maintenance.**

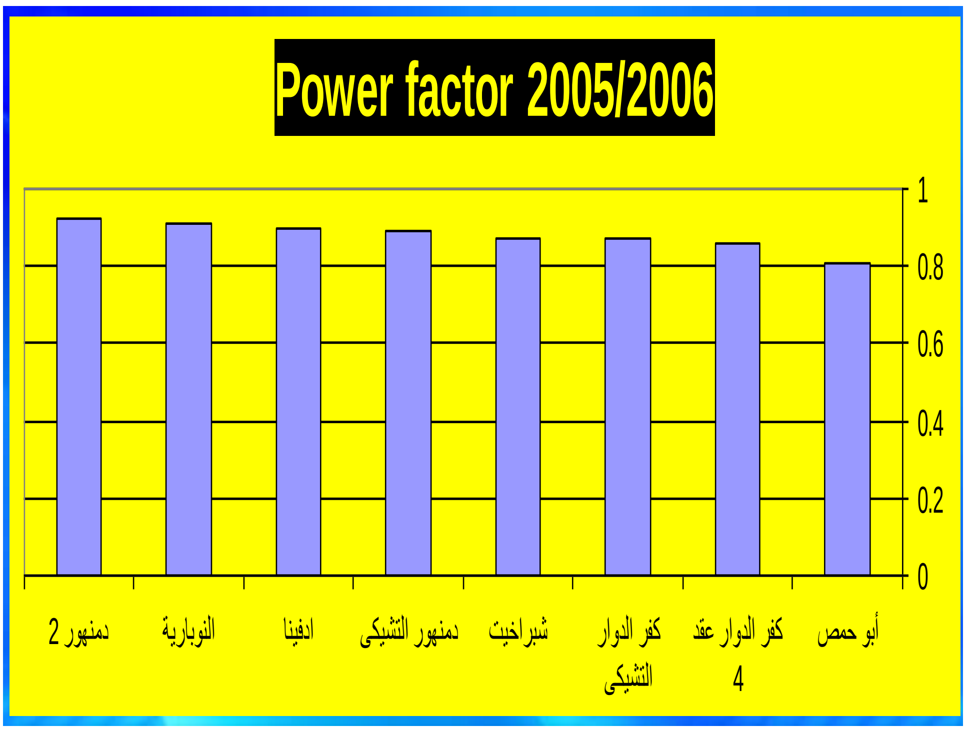
POTABLE WATER PLANTS IN AL-BEHERA

Production m3/day	محطة المياه
129019	محطة مياه كفر الدوار (التشيكى + عقد ٤)
85,446	محطة مياه دمنهور عقد ٢
53,595	محطة مياه النوبارية
76,164	محطة مياه أبو حمص
32,492	محطة مياه دمنهور التشيكى
56,188	محطة مياه شبراخيت
79,554	محطة مياه ادفينا

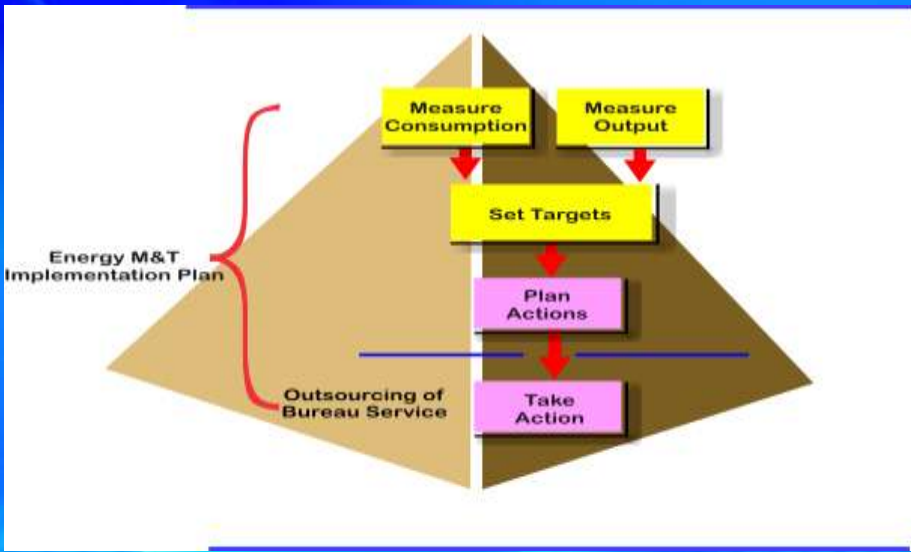
Production (m^3) 2005/2006




BENCHMARKING (Cont.)
Albehera Potable Water Pumping Stations
Specific Energy Consumption 2003/2004
0,369
0,329
0,327
0,315
0,309
0,303
0,280
0,235
0,400
0,350
0,300
0,250
0,200
0,150
0,100
0,050
0,000
kWh/m3
8
7
6
5
Station
4
3
2
1


Power factor 2005/2006
1
0.8
0.6
0.4
0.2
0
دمنهور 2
النوبارية
ادفينا
دمنهور التشيكى
شبراخيت
كفر الدوار التشيكى
كفر الدوار عقد 4
أبو حمص

Overview of the Benchmarking Activities for the Water & WW Sector



Benchmarking programme for PWWHC

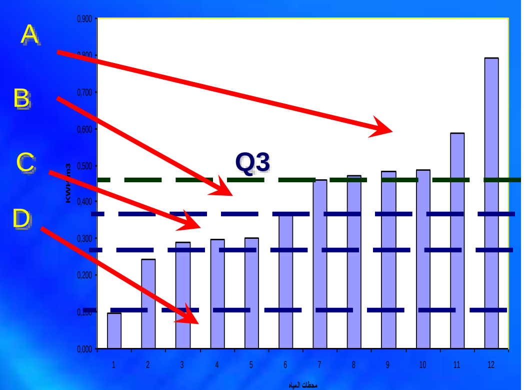
Model of Recommendations:

Example of benchmarks:

A- Have to adjust their consumption to "Q3" as a minimum

B & C- Acceptable for the sector

D- Very performing units (leaders)



Quick Energy Audit (QEA)

- It is a quick overview of energy use pattern and energy costs.
- It is necessary for setting the energy accounting system.
- It is used to preliminarily identify energy wastes as well as to define the energy conservation opportunities (ECOs).
- It is a necessary base for a detailed energy audit.

Detailed Energy Audit (DEA)

- Detailed energy audit is more detailed, sophisticated and time consuming than QEA.
- It involves actual measurements of plant operating equipment and efficiencies, calculations of energy balances and uses in different areas of the plant or facility.
- Results of the DEA are specific, detailed recommendations to save energy with a financial analysis of each one to demonstrate its cost effectiveness.

EFFECTIVE STRATEGY

A well proven energy management strategy should help in measuring current energy performance, set goals, track savings and reward improvements

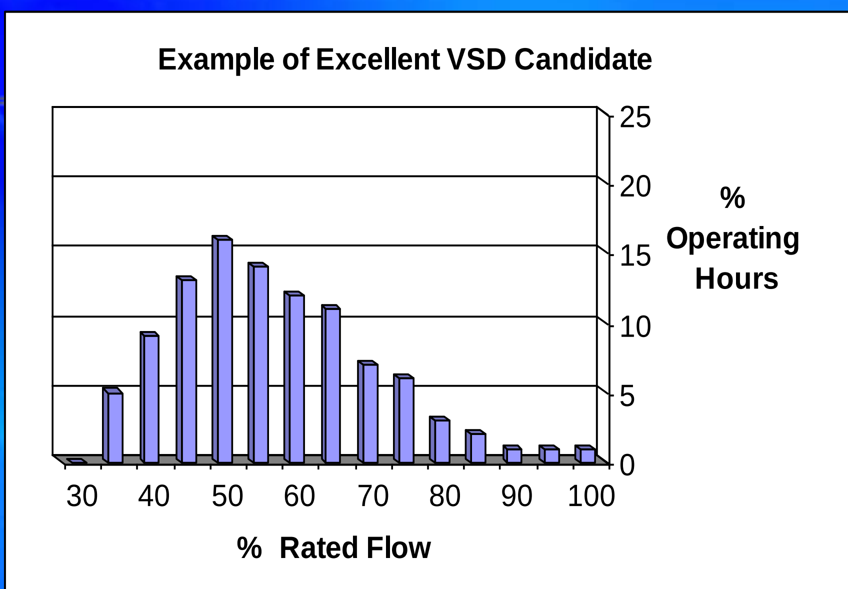
5. ENERGY EFFICIENCY POTENTIAL IN WT & WWT PLANTS

The Following are Well-Proven Energy Efficiency Technologies Applied in WT and WWT Plants:

1. *Variable Frequency Drives (WT & WWT)*
2. *Combined Heat and Power (CHP) or <u>COGENERATION</u> (WWT)*
3. *Power Factor Improvement (WT & WWT)*
4. *Efficient Aeration Process (WWT)*
5. *Efficient Use of Stand-by Generators (WT & WWT)*
6. *Load Management (WT & WWT).*
7. *Improved Maintenance*

VARIABLE FREQUENCY DRIVES

- Installing VFDs on the primary feed pumps and product transfer pumps will save much energy by reducing losses through flow control valves.
- Applied in Damanhour 2 Water Plant in Cooperation with Danish Water Utility of Amsterdam.
- The Specific Energy Consumption (SEC) reduced from 0.32 kWh/m^3 to 0.27 kWh/m3.
- Amount of annual energy saving = 1221.6 MWh of cost LE 219881 (energy cost = LE 0.18 / kWh)



POWER FACTOR IMPROVEMENT

1. Direct Benefits

- Simply the penalty will be removed.
- The HCWW has 135 Facilities with PF not improved, with a total imposed penalty about 10 million LE.
- No Water Treatment plant in Cairo has PF improves (see Figure)

2. Indirect Benefits:

- Reduced kVA
- Increased system capacity
- Reduced losses, …. Etc.

EFFICIENT AERATION PROCESS

•

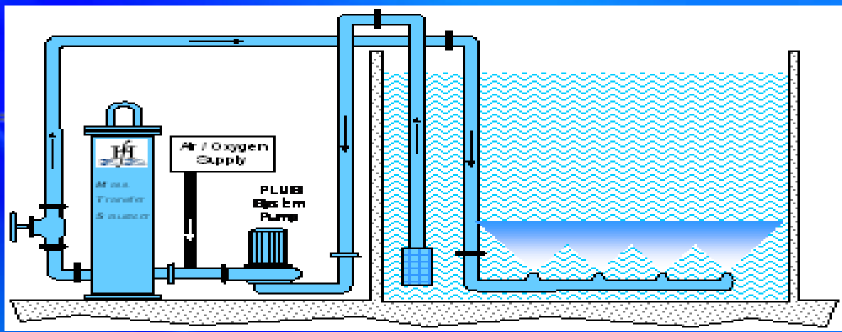
- There are several different methods of providing aeration. All methods have the same basic purpose, namely to introduce oxygen into the treatment process in the most efficient manner.
- This oxygen is essential to sustain the beneficial bacteria that consume the pollutants.

EFFICIENT AERATION PROCESS

A good starting point for energy savings is the aeration plant. Pumping air to aeration tanks can account for over 70% of the energy consumption on a typical sewage treatment plant. Regulated dissolved oxygen (DO) levels optimise the rate of tank aeration and reduce pumping requirements.

EFFICIENT AERATION PROCESS

- **SURFACE AERATION**:
  Low efficiency and high energy consuming.
- **DIFUSED AERATION:**
  Energy-saving More than 50% of the power was attributed to aeration. By replacing your aeration system from mechanical aerators, you could half your electricity bill.
- **JET AERATION SYSTEM:**
  Is custom engineered to provide efficient oxygen transfer and mixing in biological WWT plants.



What makes it more efficient?

The saturator yields bubble sizes of 1 to 10 microns in diameter. The smaller the bubbles, the higher the surface area which yields the most efficient oxygen transfer. These smaller bubbles also rise at a significantly lower rate, giving the oxygen more time to absorb into the parent fluid.

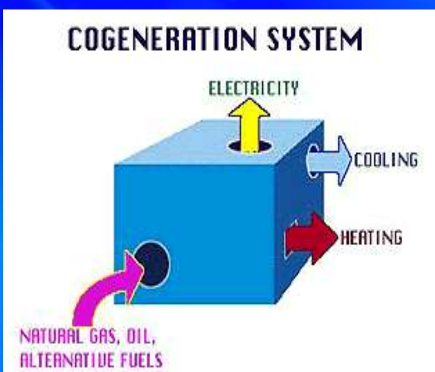
EFFICIENT AERATION PROCESS

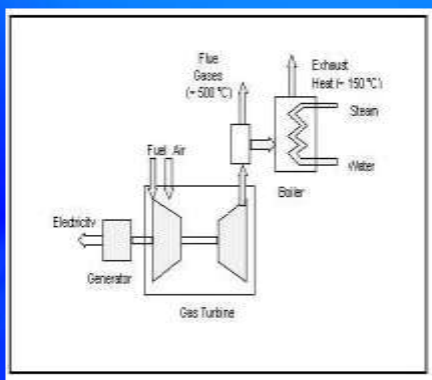
Jet aeration system

EFFICIENT USE OF STAND-BY GENERATORS

- Cairo WWC has more than 10 MVA installed capacity of Stand-by generators.
- These generators are not used efficiently.
- Connecting large Stand-by generators with the grid will save money for both Electric Utility (at peak demand) and Cairo WWC.

COMBINED HEAT & POWER (CHP) (COGENERATION)



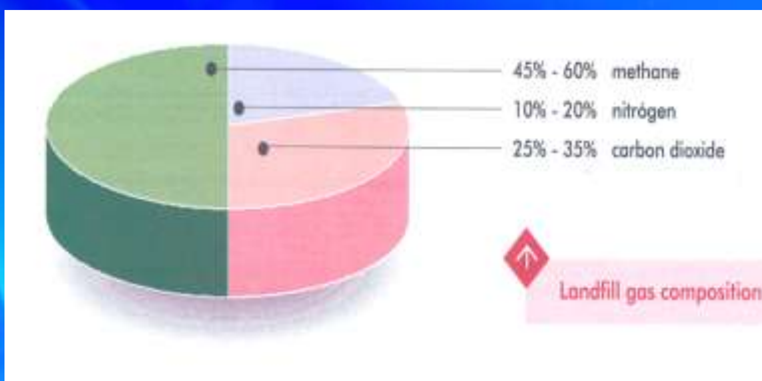


ENGINEERING RULES OF THUMB FOR CONSIDERING CHP IN WWTPs

- A typical WWTF processes 0.38 m3 per day of wastewater for every person served.
- Approximately 1.0 cubic foot (ft3) of digester gas can be produced by an anaerobic digester per person per day. This volume of gas can provide approximately 2.2 Watts of power generation.
- The heating value of the biogas produced by anaerobic digesters is approximately 600 British thermal units per cubic foot (Btu/ft3).
- For each 4.5 MGD processed by a WWTF with anaerobic digestion, the generated biogas can produce approximately 100 kilowatts (kW) of electricity.

CHP IN WASTEWATER TREATMENT PLANTS

Gasification of Sludge in Anaerobic Digesters and use the gas for Cogeneration in gas engines



CHP IN WASTEWATER TREATMENT PLANTS (Cont.)

Another method for CHP:

By Direct Firing of Sludge in a Fluidized Bed Boiler and use the Generated Steam for Electricity Production in a Steam Turbine.

Albert Lea Wastewater Treatment Plant with120 kW CHP Application

- **Fuel Type:** **Digester (Methane) gas.**
- **Prime Movers:**

(4) 30 kW Capstone Micro-turbines.

- **Annual Energy Savings:**

  $ 40,000 - $ 60,000

- **Implementation Cost:** **$ 250,000**
- **Payback Period:**
  - Less than 2 years – City of Albert Lea,
  - 4-6 years – Total project
- **Year Installed:** 2003

Wastewater Plant "Ina Road WWTF" With CHP (Cogeneration)

- **Plant Capacity:** 132500 m^3/day (35 MGD)
- **Generating Capacity:** 2.5 MW of electricity & thermal energy used for hot water, chilled water and HVAC; and to run the anaerobic digesters.

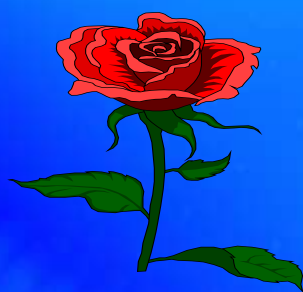
PLAN FOR ENERGY EFFICIENCY (BASICS FOR HCWW GUIDELINES)

- *Short -Term Plan.*
- *Medium -Term Plan.*
- *Long -Term Plan.*

EXAMPLE OF SHORT- TERM PLAN

- Assign an Energy Manager in large Water and Wastewater Plants (WWP).
- Reduce leakage in WWPs and in water network.
- **Load Management:**
- ***Operate pumps at maximum efficiency.***
- ***Parallel operation is switched ON or OFF according to rate of flow and pressure.***
- ***Transformer loading.***
- ***Use of stand-by generators at peak demands.***

THANK YOU



GROUNDING SYSTEM FOR INDUSTRIAL FACILITIES

Dr. Ahmed Khozam
Energy Efficiency Improvement & Greenhouse Gas Reduction

CONTENTS

- What is Grounding (Earthing) ?
- Why Grounding ?
- What are The Types of Grounding ?
- What are Grounding Standards ?
- What is a Ground Fault ?
- What are Grounding Components ?
- Earthing Recommendations.
- Conclusions.

INTRODUCTION

- ***This is a brief introduction to the basics of grounding (earthing) of electrical systems. It is not only very important, but also a source of greatest confusion in the understanding of electric power distribution.***
- ***Detailed design and specifications are site specific and depends on many factors, such as type and condition of electrical system, soil parameters, equipment used** , …etc.*

WHAT IS GROUNDING (EARTHING) ?

Note:

In UK people have "earth", and in USA they have "ground". They are exactly the same, only different terms are used in different countries.

Definition:

A grounded system is one in which at least one conductor or point (usually the neutral point of a transformer winding) is intentionally grounded (earthed), either solidly or through a current-limiting device.

WHAT IS GROUND ?

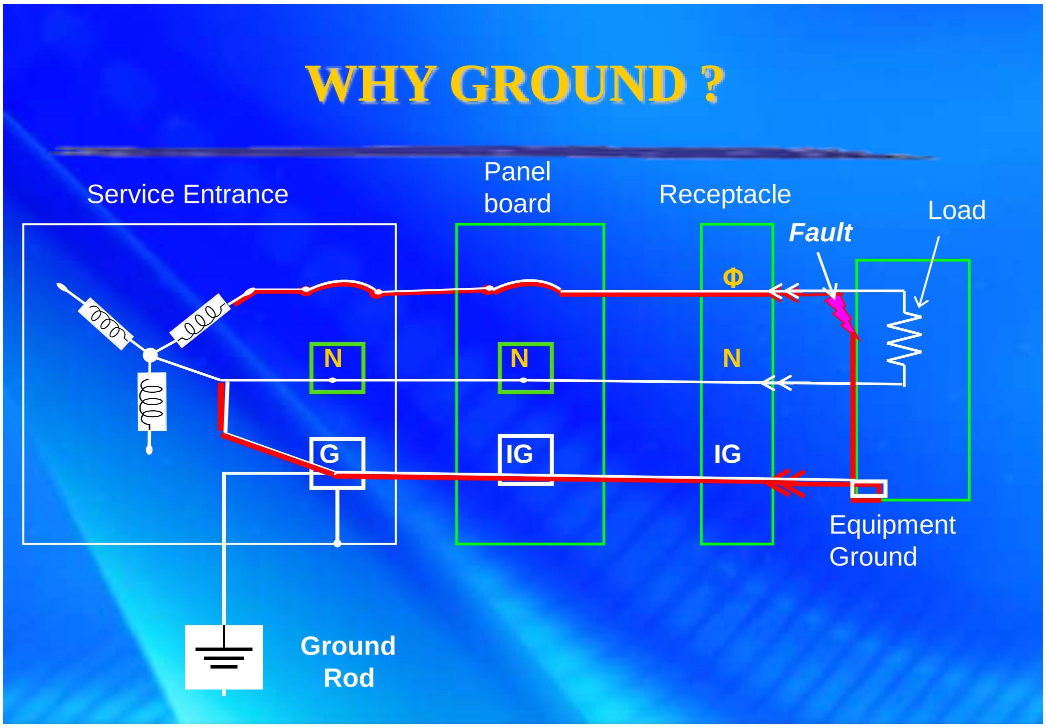
The NEC, National Electrical Code (NEC) defines a ground as:

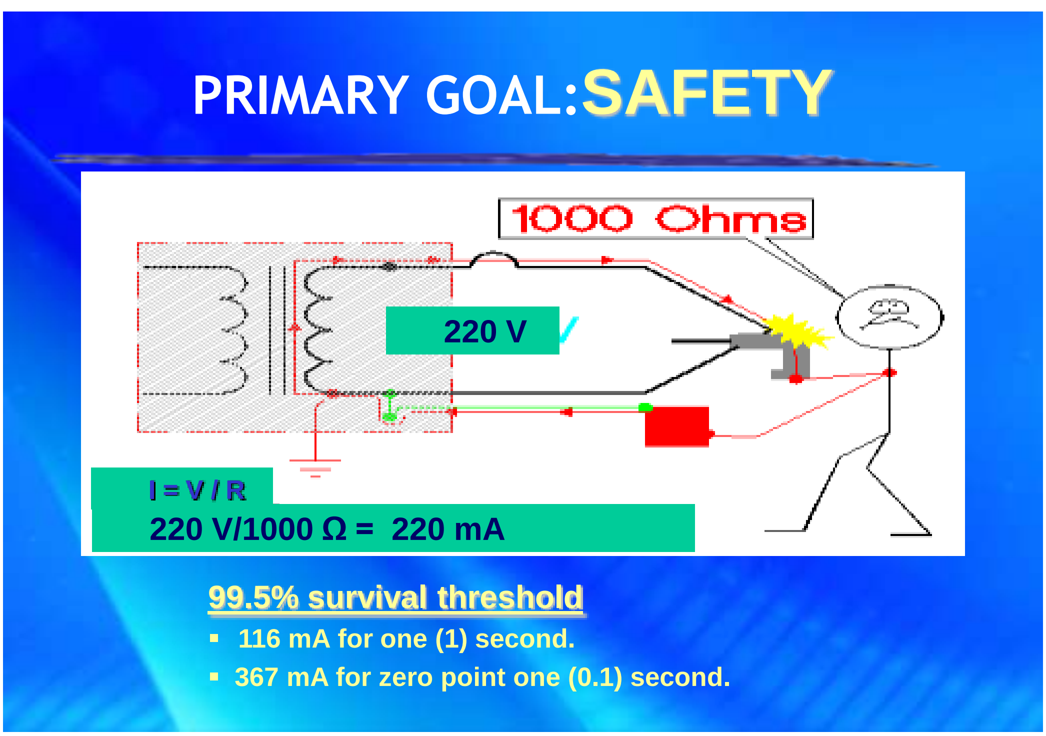
"a conducting connection, whether intentional or accidental between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth."

WHY GROUND ?

1. *As a common reference for different sources.*
2. *Protect against lightning, line surges, or any higher voltage lines. It minimize damage.*
3. *Provide an alternative path of fault current.*

SAFETY IS THE PRIMARY OBJECTIVE OF GROUNDING


WHY GROUND ?
Service Entrance
Panel
board
Receptacle
Load
Fault
Φ
N
N
N
G
IG
IG
Equipment
Ground
Ground
Rod


PRIMARY GOAL:SAFETY
1000 Ohms
220 V
I = V / R
220 V/1000 Ω = 220 mA
99.5% survival threshold
116 mA for one (1) second.
367 mA for zero point one (0.1) second.

WHAT ARE GROUNDING TYPES?

Talking about GROUNDING we have to differentiate between two different subjects:

- *System grounding, and*
- *Equipment grounding.*

GROUNDING FUNDAMENTALS (Cont.)

That is why the recent practice is to use a metallic conductor, as the return path for the fault current. This conductor is termed the ‘PEN’ conductor (in TN-C systems) or the ‘PE’ conductor (in TN-S systems). The PEN or the PE conductor are earthed at one or many places along its length, only to bring its potential close to the earth potential, which, conventionally is taken as zero (vide Cl. 2.7 of IS 3043).

SYSTEM & EQUIPMENT GROUNDING

- ***System grounding:*** is an intentional connection from a circuit conductor usually the neutral to a ground electrode placed in the earth.
- ***Equipment grounding:*** is to ensure that operating equipment within a structure is properly grounded.

EQUIPMENT GROUND

An equipment ground is the physical connection to earth of non-current carrying metal parts. This type grounding is done so that all metal part of equipment that personnel can come into contact with are always at or near zero (0) volts with respect to ground. All metal parts must be interconnected and grounded by a conductor in such away as to ensure a path of lowest impedance for flow of ground fault current. Typical items (equipment) to be grounded are; electrical motor frames, outlet boxes, breaker panels, metal conduit, support structures, cable trays, … etc.

EQUIPMENT GROUNDING

Equipment grounding must comply with the National Electric Code (NEC) Article 250. All noncurrent-carrying metal enclosures for electrical equipment or wiring must be grounded.

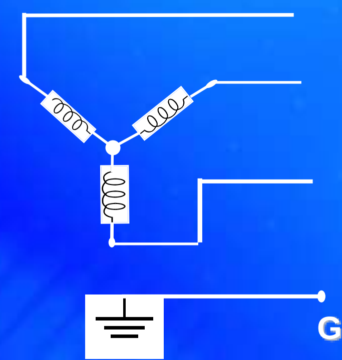
Equipment grounding means a continuous copper conductor connected between the grounding electrode (rod/grid) connection, at the source transformer, and at each enclosure and equipment frame.

WHAT ARE THE TYPES OF GROUNDING SYSTEMS ?

- Ungrounded System
- Solidly Grounded System
- Low Resistance Grounded System
- High Resistance Grounded System

UNGROUNDED SYSTEM

Ungrounded Power System

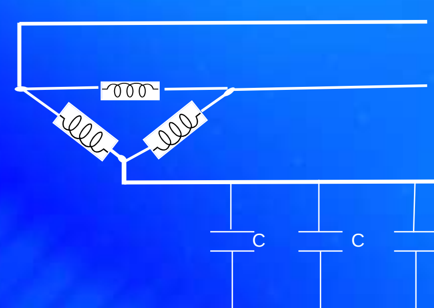


An Ungrounded system is one in which there is no intentional connection between the conductors and earth.

However as in system, a capacitive coupling exists between th system conductors and the adjacent ground surfaces. Consequently, the "ungrounded system" is in reality a ""capacitively grounded system" by virtue of the distributed capacitance.

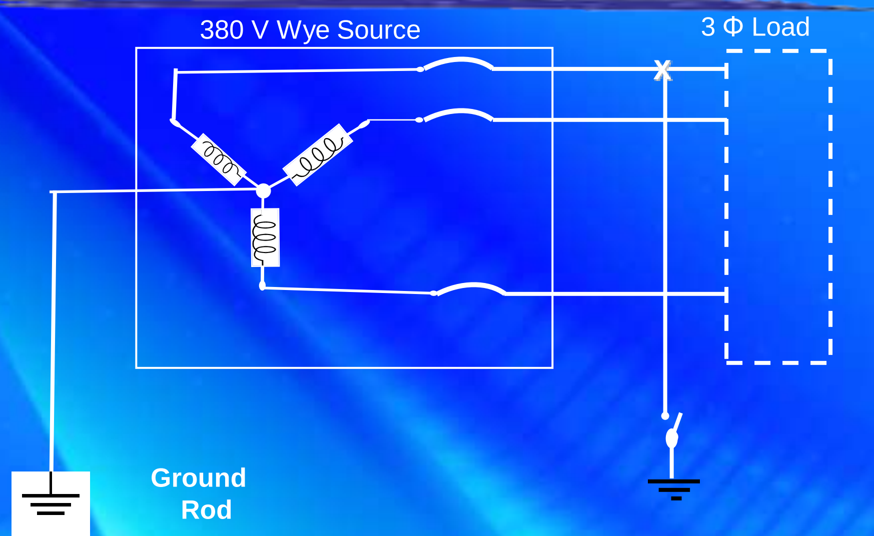
UNGROUNDED SYSTEM

Ungrounded Power System



- *An Ungrounded system may typically used in Delta services.*
- *Ungrounded systems have the ability to continue to operate with a single ground fault. This will raise the potential to ground of the remaining two ungrounded phases to their full line – to – line value.*

SOLIDLY ROUNDED SYSTEMS

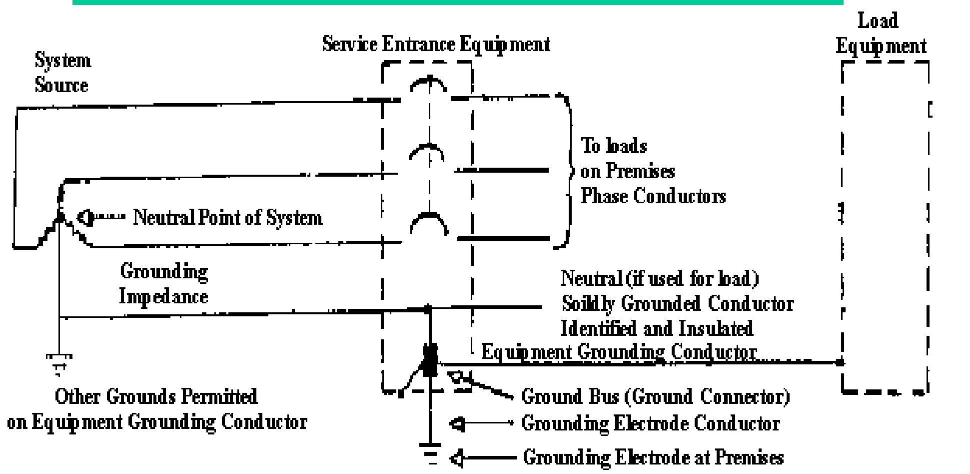


SOLIDLY ROUNDED SYSTEMS

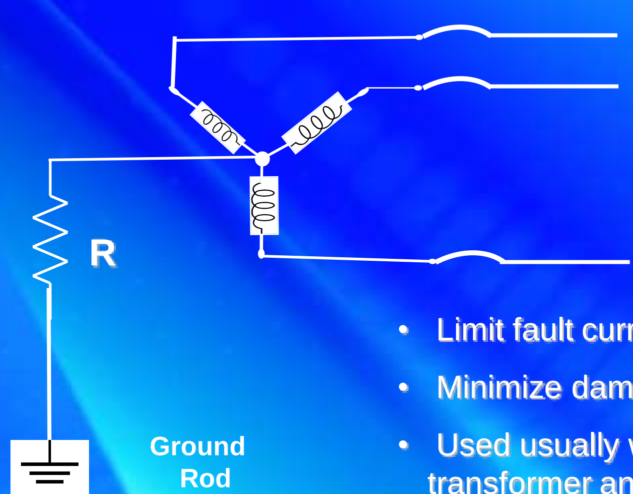
- Usually used in Y systems.
- Permit line-to-neutral loads
- Return fault current to trip over-current protection device quickly.
- Usually better reference and safer system.
- Much better for lightning protection.
- Can be used in Corner grounded delta.
- Disadvantage:
  - * Danger from low level arcing faults.
  - * Strong shock hazard to personnel.

SYSTEM GROUNDING

SOLIDLY GROUNDED SYSTEM

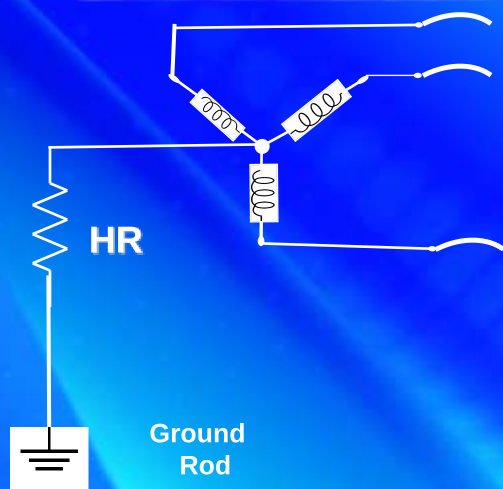


LOW RESISTANCE GROUNDING



- Limit fault current
- Minimize damage at the fault
- Used usually with multiple sources, i.e. transformer and generator.

HIGH RESISTANCE GROUNDING



High-Resistance Grounding of, an electrical power system, is the grounding of the system neutral through a resistance which limits ground-fault current to a value equal to, or slightly greater than the capacitive charging current of that system.

It enable system to operate with on phase grounding.

Current is low enough so that no damage occurs.

Enable current to flow for detection networks.

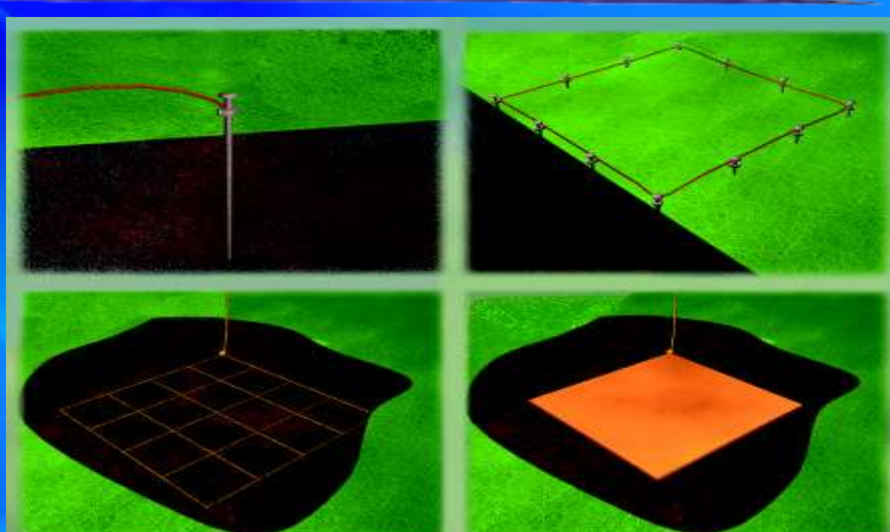
Standard Industrial System Grounding Methods

Characteristics	Methods of System Grounding			
	Ungrounded	Solid Ground	Low Resistance Ground	High Resistances Ground
Susceptible to Transient overvoltages	WORST	GOOD	GOOD	BEST
Under fault conditions (line-to-ground) increase of voltage stress	POOR	BEST	GOOD	POOR
Arc Fault Damage	WORST	POOR	GOOD	BEST
Personnel Safety	WORST	POOR	GOOD	BEST
Reliability	WORST	GOOD	BETTER	BEST
Economics' (Maintenance costs)	WORST	POOR	POOR	BEST
Plant continues to operates under single line-to-ground fault	FAIR	POOR	POOR	BEST

Standard Industrial System Grounding Methods

	Methods of System Grounding			
Characteristics	Ungrounded	Solid Ground	Low Resistance Ground	High Resistances Ground
Ease of locating ground faults (time)	WORST	GOOD	BETTER	BEST
System coordination	NOT POSSIBLE	GOOD	BETTER	BEST
Upgrade of ground system	WORST	GOOD	BETTER	BEST
Two voltage levels on same system	NOT POSSIBLE	POSSIBLE	NOT POSSIBLE	NOT POSSIBLE
Reduction in number of faults	WORST	BETTER	GOOD	BEST
Initial fault current Into ground system	BEST	WORST	GOOD	BETTER
Potential flashover to ground	POOR	WORST	GOOD	BEST

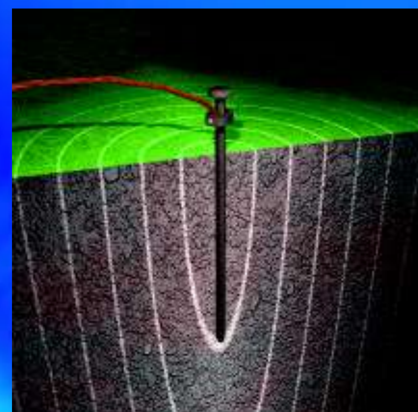
GRONDING COMPONENTS



GROUND ELECTRODE / ROD

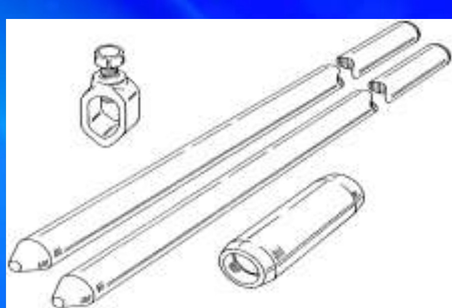
Consist of three basic components:

1. *Ground conductor*
2. *The onnection/bonding of the conductor to the ground electrode*
3. *The ground electrode itself*

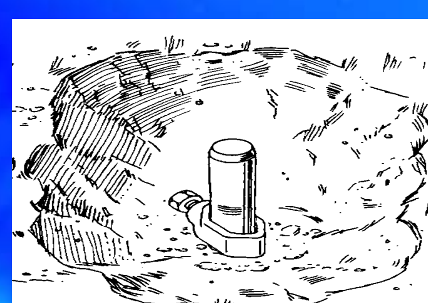


GROUND ELECTRODE / ROD

The use of a single ground electrode is the most common form of grounding and can be found outside your place of business or building.



Grounding Kit



Partially Burried Rod

RESISTANCE OF ELECTRODE

The resistance to earth of a given electrode (rod) consists of 3 components:

a) Resistanc of the electrode and connections to it.

b) The contact resistance of the electrode to the adjacent earth.

c) The resistance of the earth surrounding the electrode.

Moisture content is one of the controlling factors of earth resistivity.

GROND ELECTRODE / ROD

For Rod or Pipe Electrodes,

$$R = \frac{100\,\rho}{2\,\pi\, l} \log_e \frac{4l}{d} \quad \text{Ohms}$$

where,

ρ = Resistivity of the soil in Ohm-m

l = Length of the Rod or Pipe in cm

d = Diameter of the Rod or Pipe in cm.

PLATE RESISTANCE TO EARTH

If one considers a plate electrode, the approximate resistance to earth is:

$$R = \frac{\rho}{A}\sqrt{\frac{\pi}{A}}$$ **Ohms (IS 3043)**

where,

ρ = Resistivity of the soil in Ohm-m

A = Area of both sides of the plate in m2

GROUNDING COMPONENTS

As can be seen from the above formulae, only the resistivity of the soil and the physical dimensions of the electrode play a major role in determining the electrode resistance to earth.

The material resistivity is not considered anywhere in the above formulae.

GROUNDING: WHAT IS THE STANDARD RESISTANCE TO EARTH ?

Frequently applied Criteria:

1 - 5 Ohms Resistance to Earth

- NEC requires only twenty-five (25) ohms of resistance for made electrodes, while the
- ANSI/IEEE Standard 141 (Red Book) and ANSI/IEEE 142 (Green Book) specifies a ground resistance of one (1) to five (5) ohms.

ELECTRICAL GROUNDING STANDARDS

The standard for Electrical Grounding is covered in:

1. FIPS Publication 94: *Guideline on Electrical Power for ADP Installations 9/83*
2. IEEE Standard P1100: *Guide for Powering and Grounding Sensitive Equipment*
3. NFPA Publication 70: *The National Electric Code*
4. IEEE Standard 141: *IEEE Industrial Electric Power Systems*
5. IEEE Standard 142: *IEEE Industrial and Commercial Power System Grounding.*

DOMSTIC GROUNDING

Domestic grounding systems must prevent users and apparatus from hazardous shocks during short circuits within the building. During such a disturbance the grounded apparatus will carry a voltage relative to normal ground. This voltage is dependent on the impedances of the network components and the grounding system. When a person

touches a grounded apparatus during a disturbance his touch voltage will be a part of that voltage. This will result in a current through the body. In order to prevent victims this current must not last too long, so the fault has to be switched o® in time. Switching of the fault is done by the protection device. In most households this is a fuse or a circuit

breaker. To switch o® in time the circuit resistance needs to be low. The circuit resistance is mainly determined by the impedance of the return path. Several grounding principles

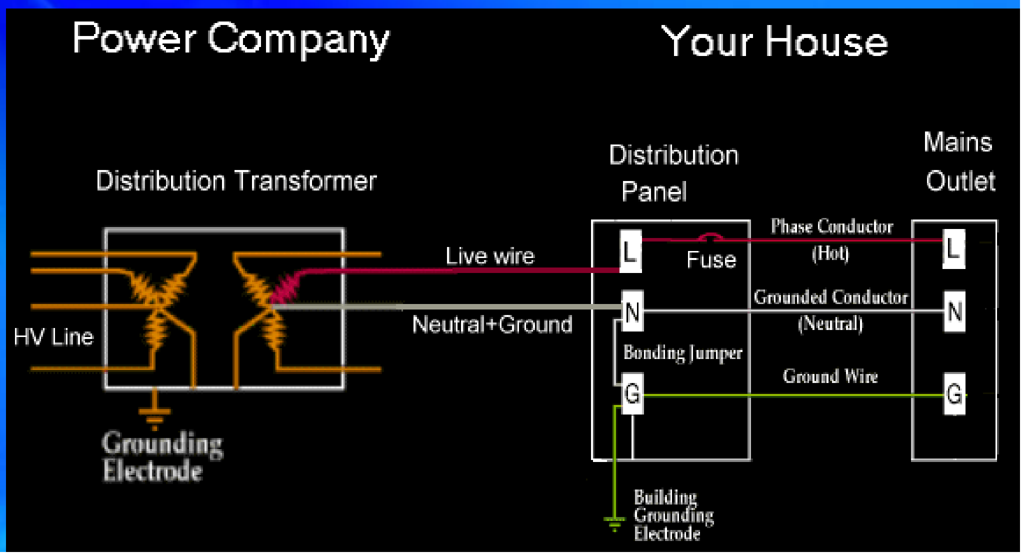
are applied nowadays (Figure 1)

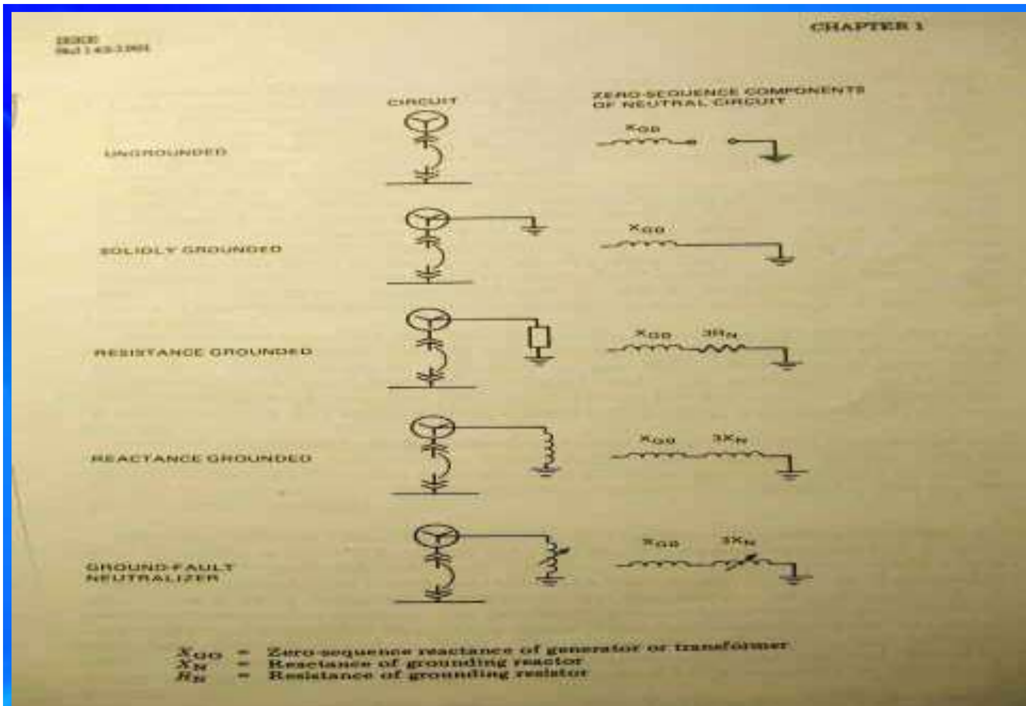
GROUNDING (EARTHING)

Good Earth Connection Should Have :

- *Low electrical resistance to earth.*
- *Good corrosion resistance.*
- *Ability to carry high current repeatedly.*
- *Reliable, cost effective and environmental friendly.*

TYPICAL SINGLE-PHASE FEEDING A SMALL BUILDING





System Failures on Industrial Power Systems

Failure Mode	Percentage of Failures
Line to Ground	98%
Phase to Phase	< 1.5%
*Three Phase	< 0.5%

PRACTICAL OBSERVATIONS

“Through error or oversight, intentional or unintentional, the grounding system in many cases is not installed in accordance with the requirements of the National/International Standards or Local Electrical Codes of Practice”. (vide Clause 6.4.1 of IEEE 1100). Even if installed properly, proper maintenance of the earthing system is questionable, mostly guided by incorrect practices.

MYTHS !

Myth 1:

Natural earth serves as a return path for fault current

Myth 2:

Copper Earth Electrodes are better than GI or Steel Earth Electrodes

Myth 3:

Plate Earthing is better than Pipe ***Earthing***

GROUNDING FUNDAMENTALS

Fact:

Though this may be true in some cases,

one would be surprised to note that natural earth is a very poor conductor of electric current. Yes!

The typical resistivity of the general mass of earth is about 100 Ohm-m. Compare this with the resistivity of Copper, which is, 1.7 x 10-8 Ohm-m (0.017 Ohm-mm2/m)

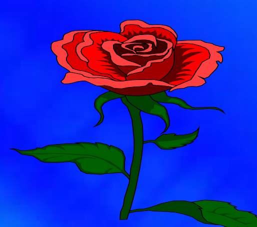
Industry Recommendations
IEEE Std 242-2001 (Buff Book)

Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems

Ungrounded Systems

8.2.5 **If this ground fault is intermittent or allowed to continue, the system could be subjected to possible severe over-voltages to ground, which can be as high as six to eight times phase voltage.** Such over- voltages can puncture insulation and result in additional ground faults. These over-voltages are caused by repetitive charging of the system capacitance or by resonance between the system capacitance and the inductance of equipment in the system.

THANK YOU

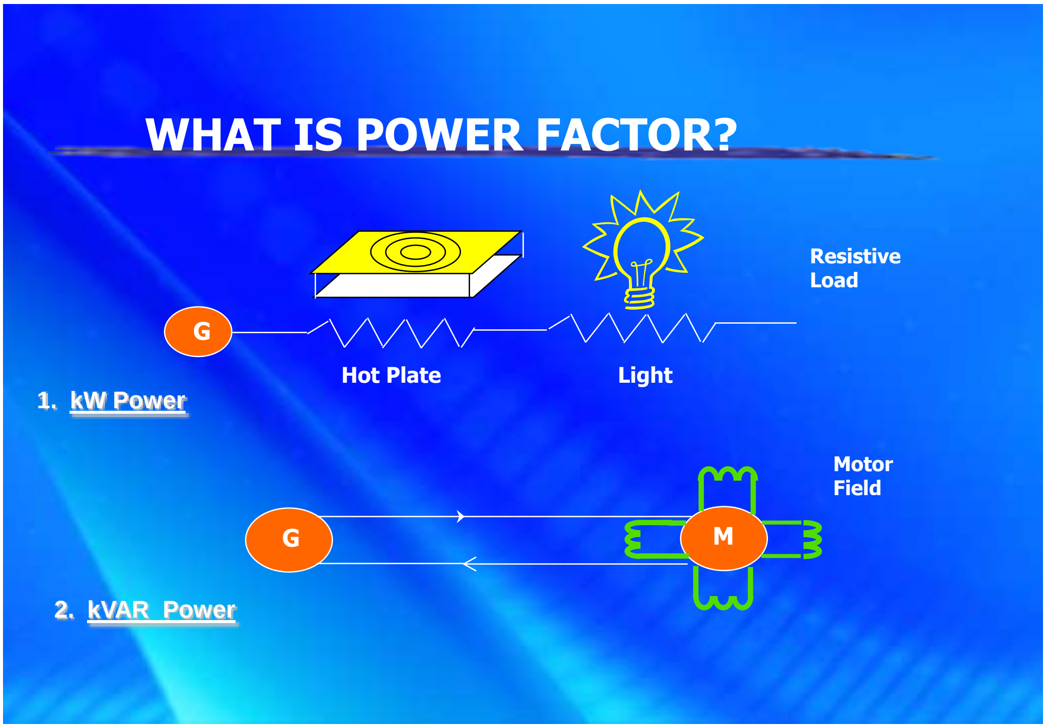


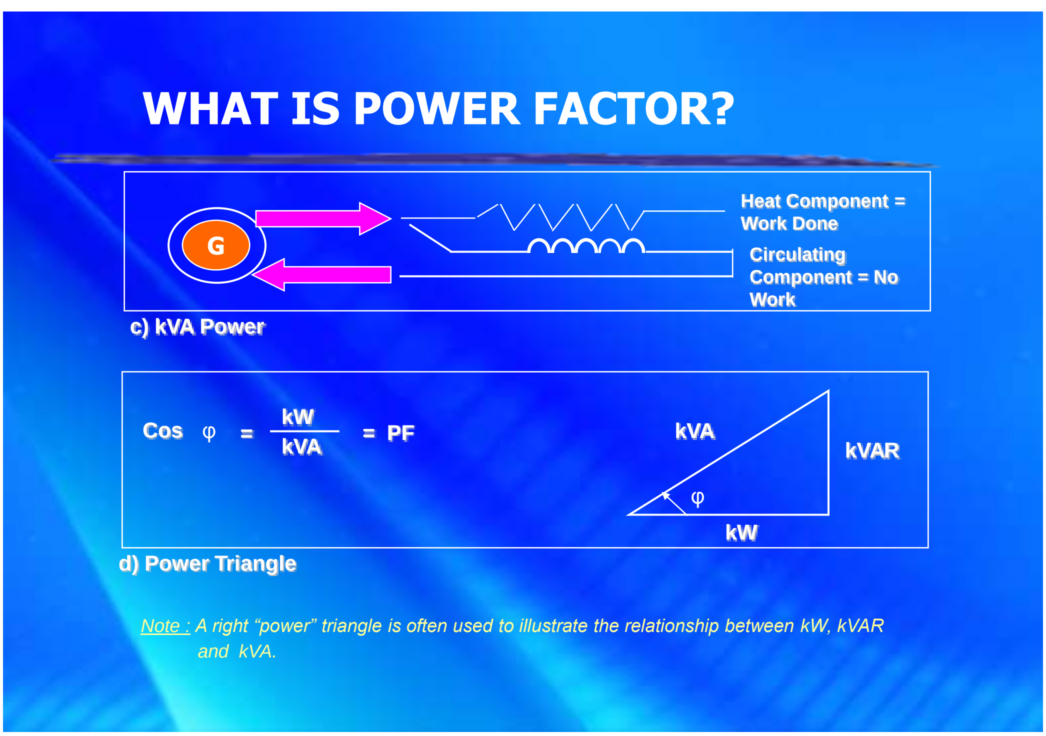
POWER FACTOR IMPROVEMENT

Dr. Ahmed Khozam
Energy Efficiency Improvement & Greenhouse Gas Reduction

TOPICS TO BE COVERED:

- What is Power Factor (PF) ?
- Why Improved PF ?
- *How to Improve PF ?*
- *What is The Best Location of Capacitors and Capacitor Banks ?*
- *What Problems Associated With PFI Projects ?*


WHAT IS POWER FACTOR?
Resistive Load
G
Hot Plate
Light
1. kW Power
Motor Field
G
M
2. kVAR Power


WHAT IS POWER FACTOR?
G
Heat Component = Work Done
Circulating Component = No Work
c) kVA Power
Cos φ = kW / kVA = PF
kVA
kVAR
φ
kW
d) Power Triangle
Note : A right "power" triangle is often used to illustrate the relationship between kW, kVAR and kVA.

POWER FACTOR OF STANDARD LOADS

Type of Load		Cos φ
Standard Induction Motor under a Load of:	0%	0.17
	25%	0.55
	50%	0.73
	75%	0.80
	100%	0.85
Incandescent Lamp		1
Fluorescent Lamp		0.5
Discharge Lamp		0.4 to 0.6
Static Monophase Arc Welding		0.5
Arc Furnace		0.8
Thyrestor based Power Rectifier		0.4 to 0.8

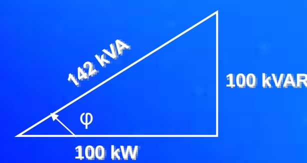
INDUSTRIES WITH LOW POWER FACTOR

Industry	Uncorrected PF
Saw Mills	45% - 60%
Plastic (esp. extruders)	55% - 70%
Machine tools, stamping	60% - 70%
Plating, textiles, chemicals	65% - 75%
Hospitals, granularies, foundries	70% - 80%

WHAT ARE THE BENEFITS OF PF IMPROVEMENT ?

Low PF means you are not utilizing the electrical power you are paying for.

- At 70% PF, it requires 142 kVA to produce 100 kW
- At 95% PF, it requires only 105 kVA to produce 100 kW
- That is, at 70% PF, it takes 35% more current to do the same work.



$$PF = \frac{100}{142} = 70\%$$

$$PF = \frac{100}{142} = 95\%$$

1. Direct Benefits

- Simply You will not pay **PENALTIES** any more.
- More over after “Pay back Period”, instead of paying, **YOU WILL SAVE ALL PENALTIES TO BE PAID.**

HOW PENALTIES ARE CALCULATED ?

0.9 > PF > 0.7	(0.9 – PF) * 1 * Energy Cost
PF < 0.7 for 3 months	(0.9 – PF) * 1.5 * Energy Cost
PF < 0.7 for 6 months	(0.9 – PF) * 2 * Energy Cost

2. Indirect Benefits

- Reduced kVA
- Reduced Losses
- *Improved Voltage*
- *Increased System Capacity*

Example: A plant has a 500 kVA transformer operating near capacity. It draws 480 kVA or 730 A at 380 V. The percent PF is 75%, so the actual working power available is 380 kW.

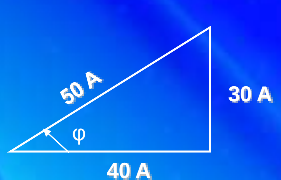
It is required to increase loads by 25%, which means that about 480 kW output must be obtained. How this can be achieved ? With the same PF (75%), the transformer should be upgraded to 600 kVA rate. Most likely, the next size standard rating would be needed (750 kVA). A better solution is to improve PF from 75% to 95% (by installing about 250 kVAR capacitor bank) and release enough capacity to accommodate the increased load.

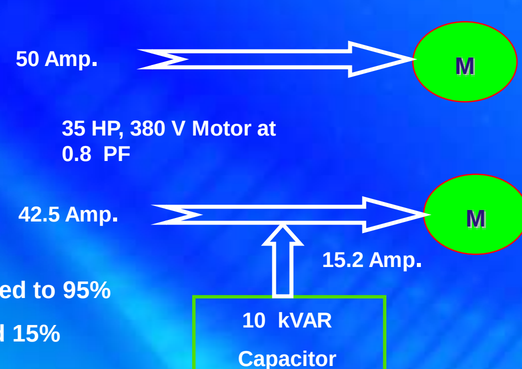
HOW TO IMPROVE POWER FACTOR ?

- Most common method is to install **CAPACITORS** or **CAPACITOR BANKS**
- Power capacitor act as reactive Current generators.
- Advantages:
  - No consumption of active energy
  - Low cost
  - Easy to install
  - Expected life duration (10-15 years)
  - Low level of maintenance (static equipment)

How Capacitors Reduce Total Line Current ?

By providing the reactive current, they reduce the total amount of current your system must draw from the utility.





Power factor improved to 95%

Line current reduced 15%

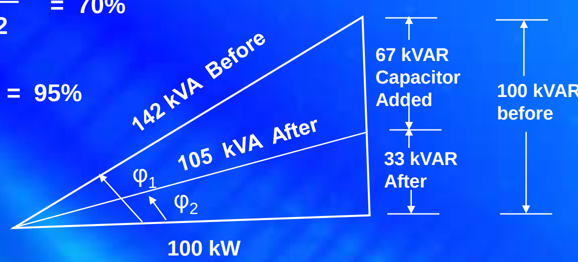
HOW TO CALCULATE THE RATED POWER OF A CAPACITOR BANK ?

95% Targeted PF Provides Maximum Benefit.

Uncorrected PF = cos φ2 $= \frac{100}{142} = 70\%$

Corrected PF = cos φ1 $= \frac{100}{105} = 95\%$

A reduction in apparent power of ~ 35% is achieved



HOW TO CALCULATE THE RATED POWER OF A CAPACITOR BANK ?

Existing PF	New PF					
	1.0	0.95	0.90	0.85	0.80	0.75
0.66	1.138					
0.68	1.078					
0.70	1.020	0.692	0.536	0.400	0.270	0.138
0.72	0.964					
0.74	0.909					
0.76	0.855					
0.78	0.802					
0.80	0.750					
0.82	0.698					
0.84	0.646	0.317	0.162	0.026		
0.86	0.593					
0.88	0.540					
0.90	0.484					
0.92	0.426					
0.94	0.363	0.034				
0.96	0.292					

WHAT IS THE BEST LOCATION OF CAPACITORS or CAPACITOR BANKS ?

Individual
- Best Solution
- Expensive (Installation & maintenance cost)

Localized
- Remove penalty
- Most economical
- Suitable for many distributed loads
- Reduce I^2R losses in cables
- Less flexible

Global
- Remove penalty
- Target PF easily attained
- No reduction in losses
- Switch gears are expensive

Location of Capacitors on Motor Circuits

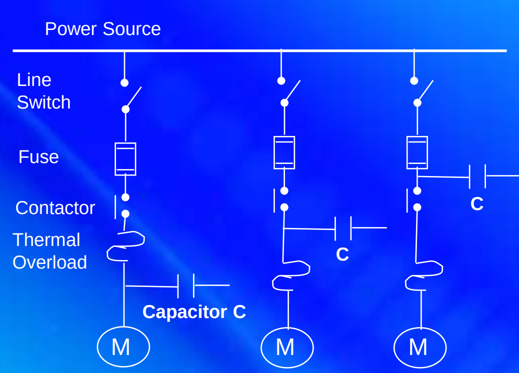
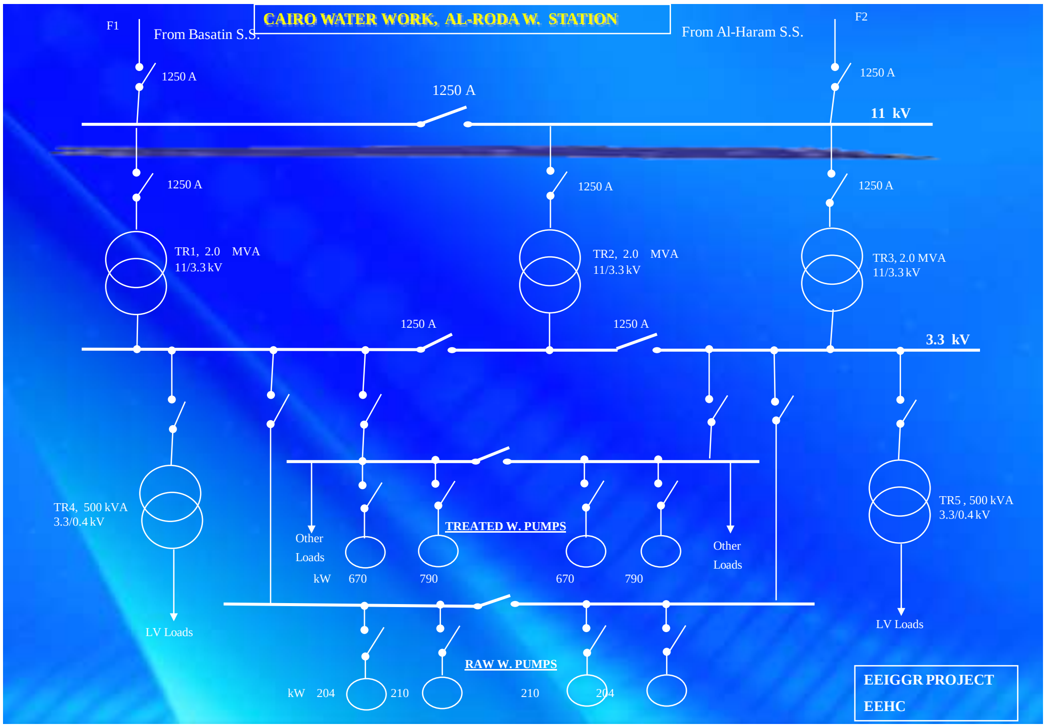


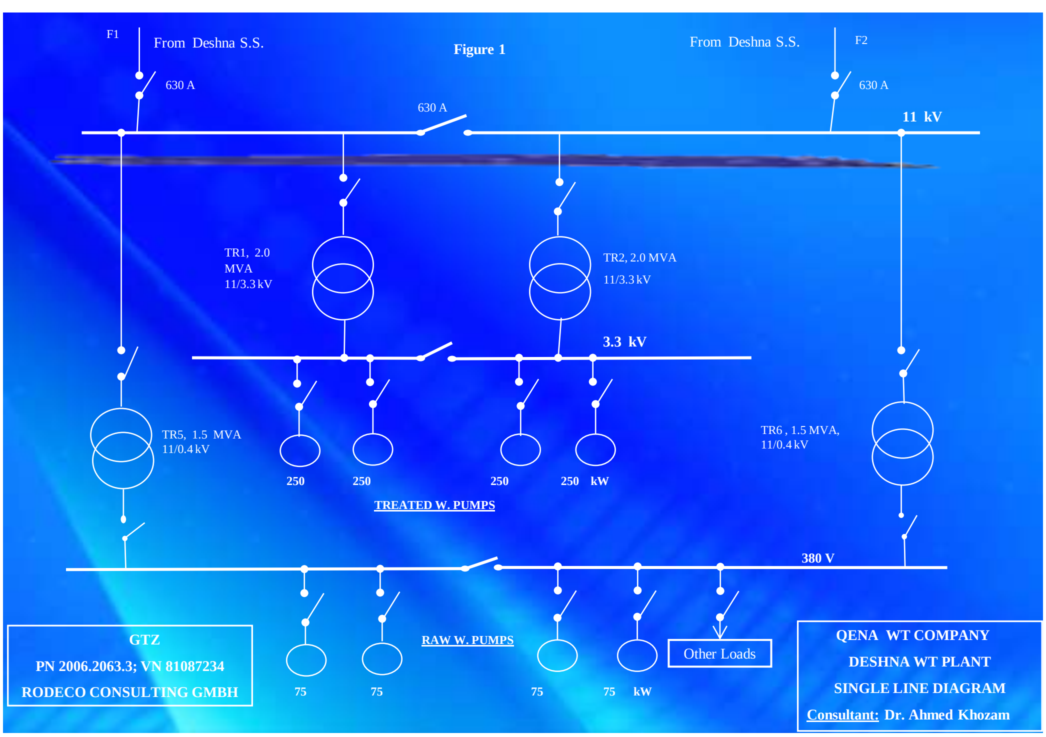
Fig. (a) Fig. (b) Fig. (c)

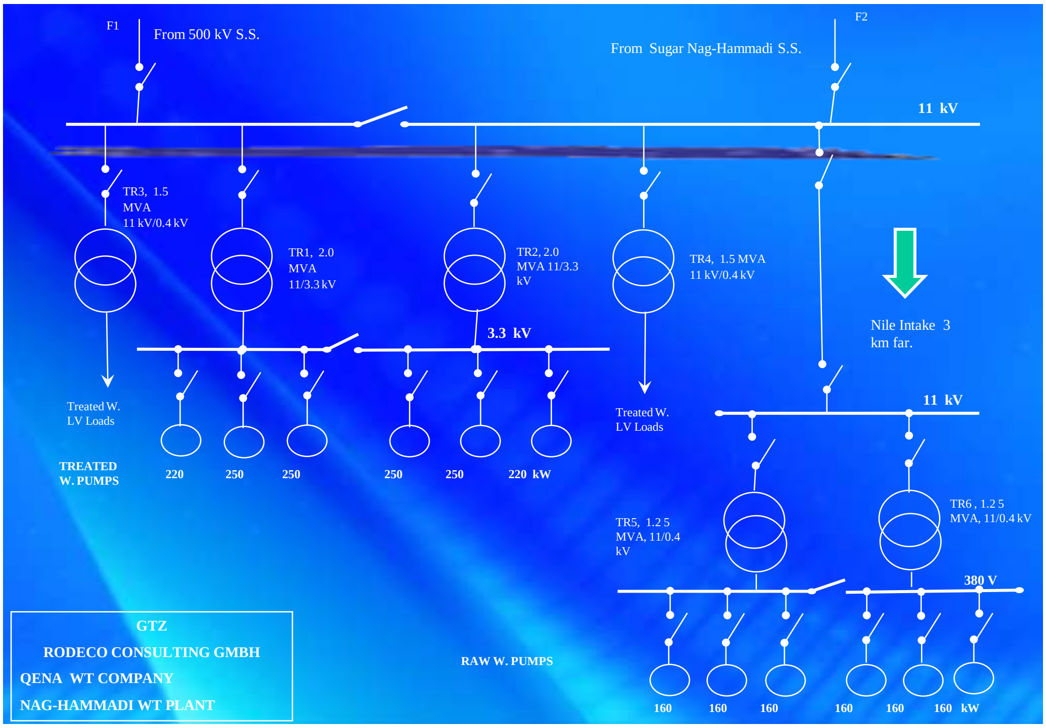
Typical Capacitor Ratings

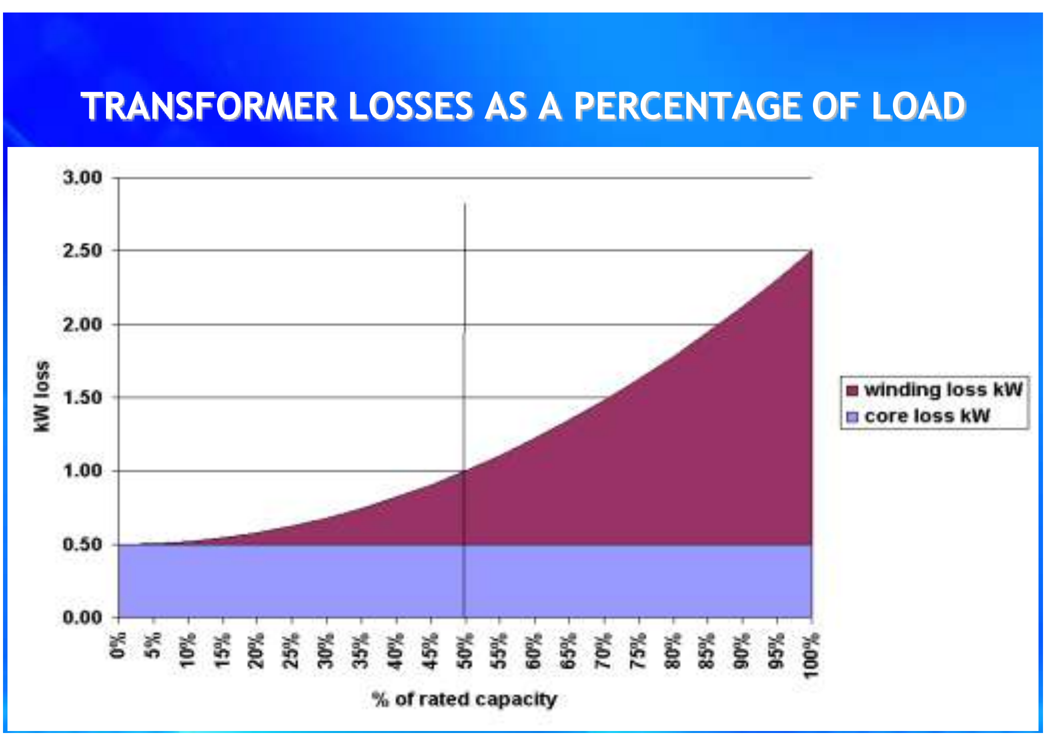
Motor (HP)	Speed (RPM)	Capacitor (kVAR)
300 400 500	1200	60 75 82.5
300 400 500	900	65 85 97.5
300 400 500	720	80 95 107.5

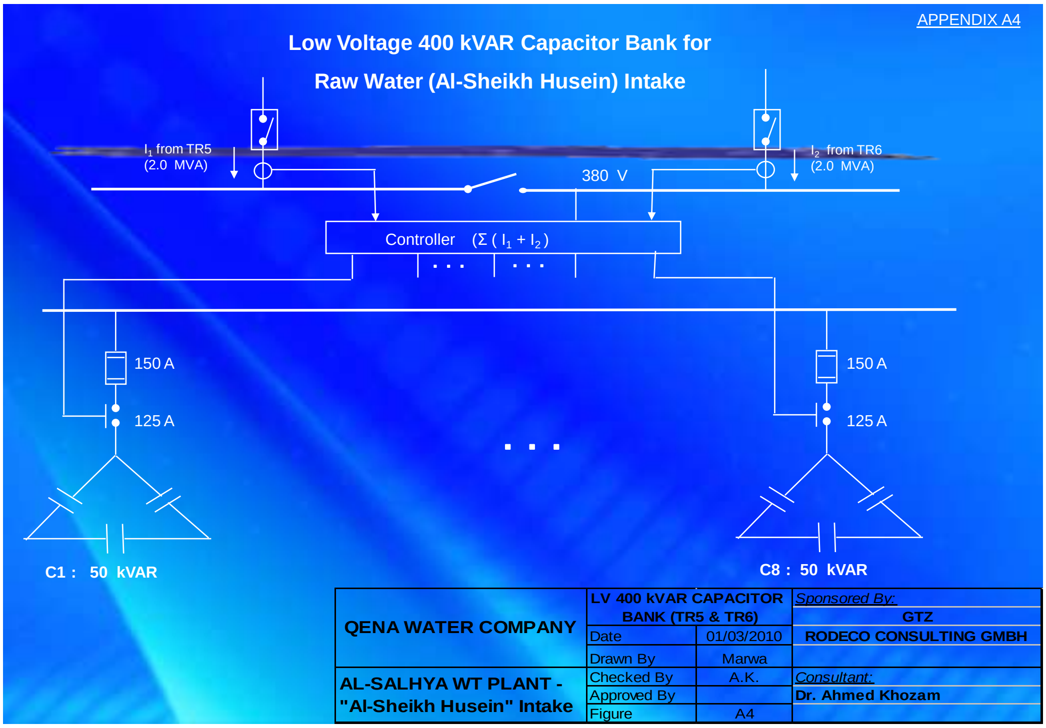
The motor type is a Pre-Frame NEMA Class B Squirrel-Cage Induction Motor

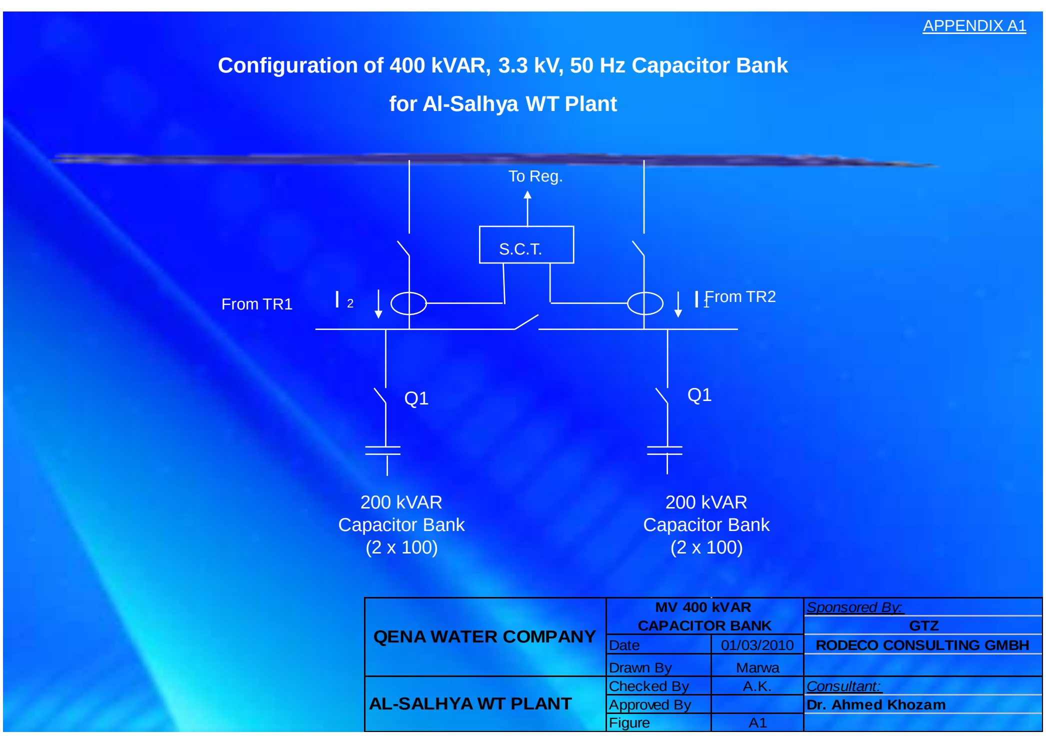

CAIRO WATER WORK, AL-RODA W. STATION
F1
From Basatin S.S.
From Al-Haram S.S.
F2
1250 A
1250 A
1250 A
11 kV
1250 A
1250 A
1250 A
TR1, 2.0 MVA
11/3.3 kV
TR2, 2.0 MVA
11/3.3 kV
TR3, 2.0 MVA
11/3.3 kV
1250 A
1250 A
3.3 kV
TR4, 500 kVA
3.3/0.4 kV
TR5 , 500 kVA
3.3/0.4 kV
Other Loads
TREATED W. PUMPS
Other Loads
kW 670
790
670
790
LV Loads
LV Loads
RAW W. PUMPS
kW 204
210
210
204
EEIGGR PROJECT
EEHC

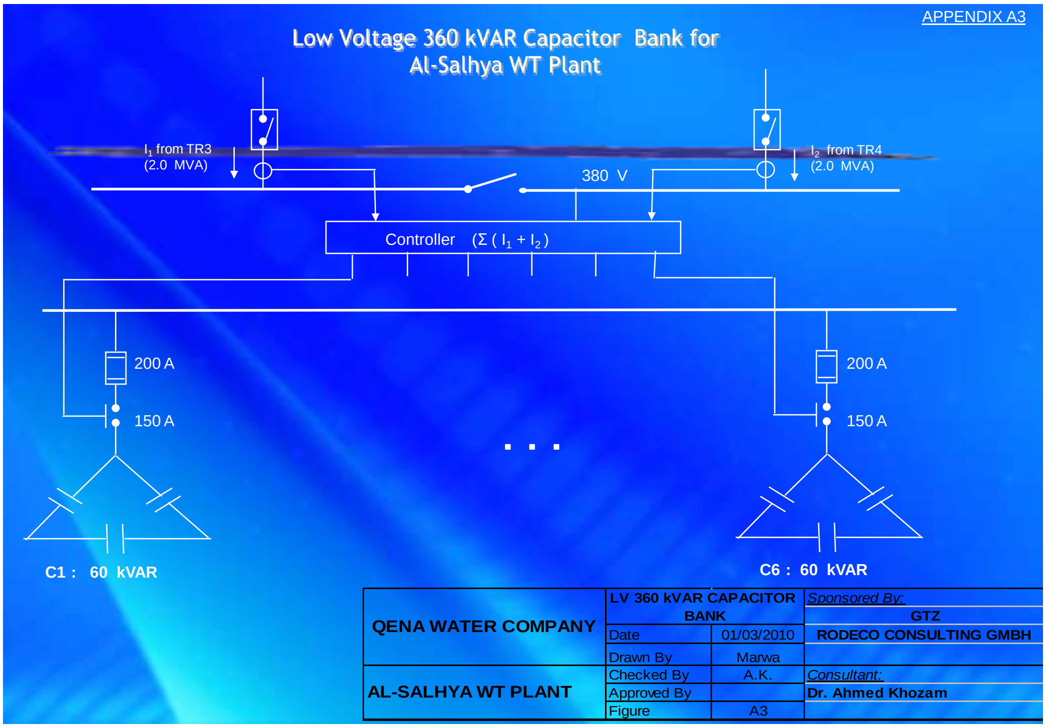

F1
From Deshna S.S.
Figure 1
From Deshna S.S.
F2
630 A
630 A
630 A
11 kV
TR1, 2.0
MVA
11/3.3 kV
TR2, 2.0 MVA
11/3.3 kV
3.3 kV
TR5, 1.5 MVA
11/0.4 kV
TR6 , 1.5 MVA,
11/0.4 kV
250
250
250
250 kW
TREATED W. PUMPS
380 V
RAW W. PUMPS
Other Loads
75
75
75
75 kW
GTZ
PN 2006.2063.3; VN 81087234
RODECO CONSULTING GMBH
QENA WT COMPANY
DESHNA WT PLANT
SINGLE LINE DIAGRAM
Consultant: Dr. Ahmed Khozam

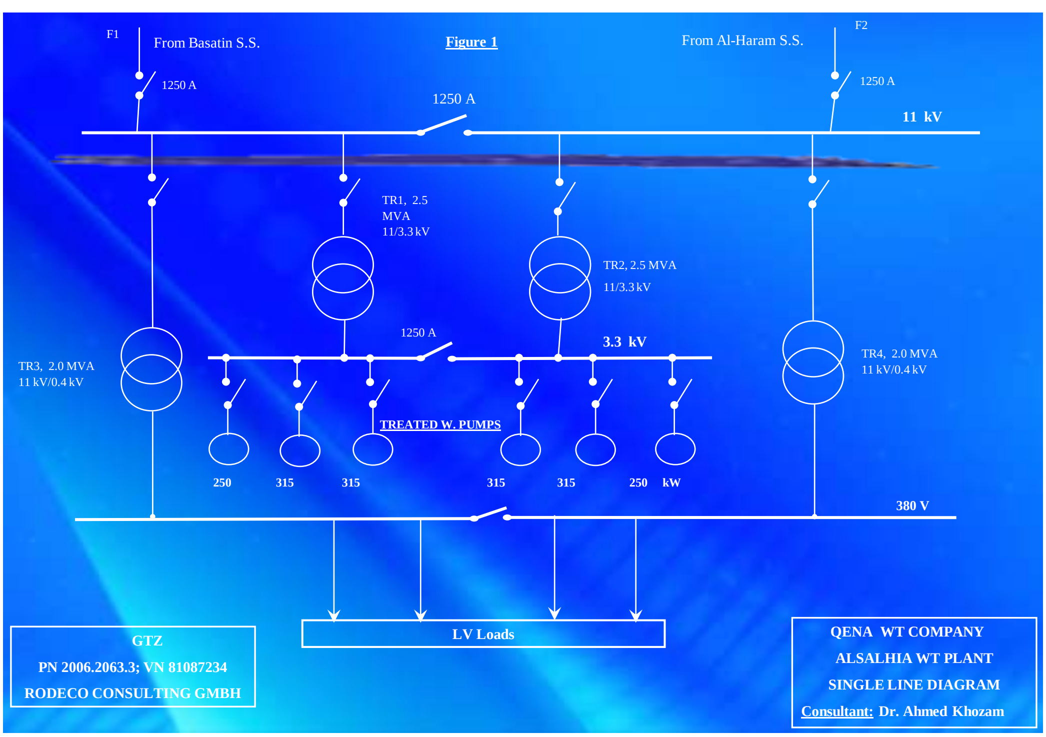

F1
From 500 kV S.S.
F2
From Sugar Nag-Hammadi S.S.
11 kV
TR3, 1.5
MVA
11 kV/0.4 kV
TR1, 2.0
MVA
11/3.3 kV
TR2, 2.0
MVA 11/3.3
kV
TR4, 1.5 MVA
11 kV/0.4 kV
Nile Intake 3
km far.
3.3 kV
11 kV
Treated W.
LV Loads
Treated W.
LV Loads
TREATED
W. PUMPS
220
250
250
250
250
220 kW
TR5, 1.2 5
MVA, 11/0.4
kV
TR6, 1.2 5
MVA, 11/0.4 kV
380 V
GTZ
RODECO CONSULTING GMBH
QENA WT COMPANY
NAG-HAMMADI WT PLANT
RAW W. PUMPS
160
160
160
160
160
160 kW


TRANSFORMER LOSSES AS A PERCENTAGE OF LOAD
kW loss
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
55%
60%
65%
70%
75%
80%
85%
90%
95%
100%
% of rated capacity
winding loss kW
core loss kW


APPENDIX A4
Low Voltage 400 kVAR Capacitor Bank for
Raw Water (Al-Sheikh Husein) Intake
I1 from TR5
(2.0 MVA)
I2 from TR6
(2.0 MVA)
380 V
Controller (Σ (I1 + I2)
150 A
125 A
150 A
125 A
C1 : 50 kVAR
C8 : 50 kVAR
QENA WATER COMPANY
AL-SALHYA WT PLANT - "Al-Sheikh Husein" Intake
LV 400 kVAR CAPACITOR BANK (TR5 & TR6)
Date 01/03/2010
Drawn By Marwa
Checked By A.K.
Approved By
Figure A4
Sponsored By:
GTZ
RODECO CONSULTING GMBH
Consultant:
Dr. Ahmed Khozam


APPENDIX A1
Configuration of 400 kVAR, 3.3 kV, 50 Hz Capacitor Bank
for Al-Salhya WT Plant
To Reg.
S.C.T.
From TR1
I 2
I 1
From TR2
Q1
Q1
200 kVAR
Capacitor Bank
(2 x 100)
200 kVAR
Capacitor Bank
(2 x 100)
QENA WATER COMPANY
AL-SALHYA WT PLANT
MV 400 kVAR CAPACITOR BANK
Date 01/03/2010
Drawn By Marwa
Checked By A.K.
Approved By
Figure A1
Sponsored By:
GTZ
RODECO CONSULTING GMBH
Consultant:
Dr. Ahmed Khozam


APPENDIX A3
Low Voltage 360 kVAR Capacitor Bank for
Al-Salhya WT Plant
I1 from TR3
(2.0 MVA)
380 V
I2 from TR4
(2.0 MVA)
Controller (Σ (I1 + I2)
200 A
150 A
200 A
150 A
C1 : 60 kVAR
C6 : 60 kVAR
QENA WATER COMPANY
AL-SALHYA WT PLANT
LV 360 kVAR CAPACITOR BANK
Date 01/03/2010
Drawn By Marwa
Checked By A.K.
Approved By
Figure A3
Sponsored By:
GTZ
RODECO CONSULTING GMBH
Consultant:
Dr. Ahmed Khozam


F1
From Basatin S.S.
Figure 1
From Al-Haram S.S.
F2
1250 A
1250 A
1250 A
11 kV
TR1, 2.5 MVA 11/3.3 kV
TR2, 2.5 MVA 11/3.3 kV
1250 A
3.3 kV
TR3, 2.0 MVA 11 kV/0.4 kV
TR4, 2.0 MVA 11 kV/0.4 kV
TREATED W. PUMPS
250
315
315
315
315
250
kW
380 V
LV Loads
GTZ
PN 2006.2063.3; VN 81087234
RODECO CONSULTING GMBH
QENA WT COMPANY
ALSALHIA WT PLANT
SINGLE LINE DIAGRAM
Consultant: Dr. Ahmed Khozam

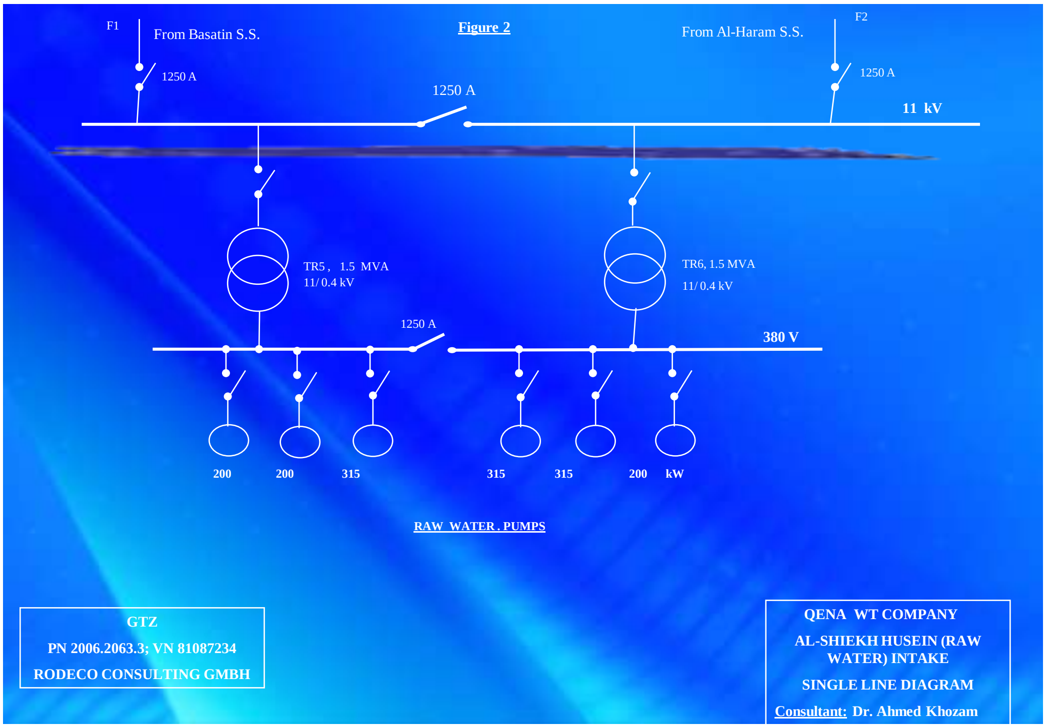
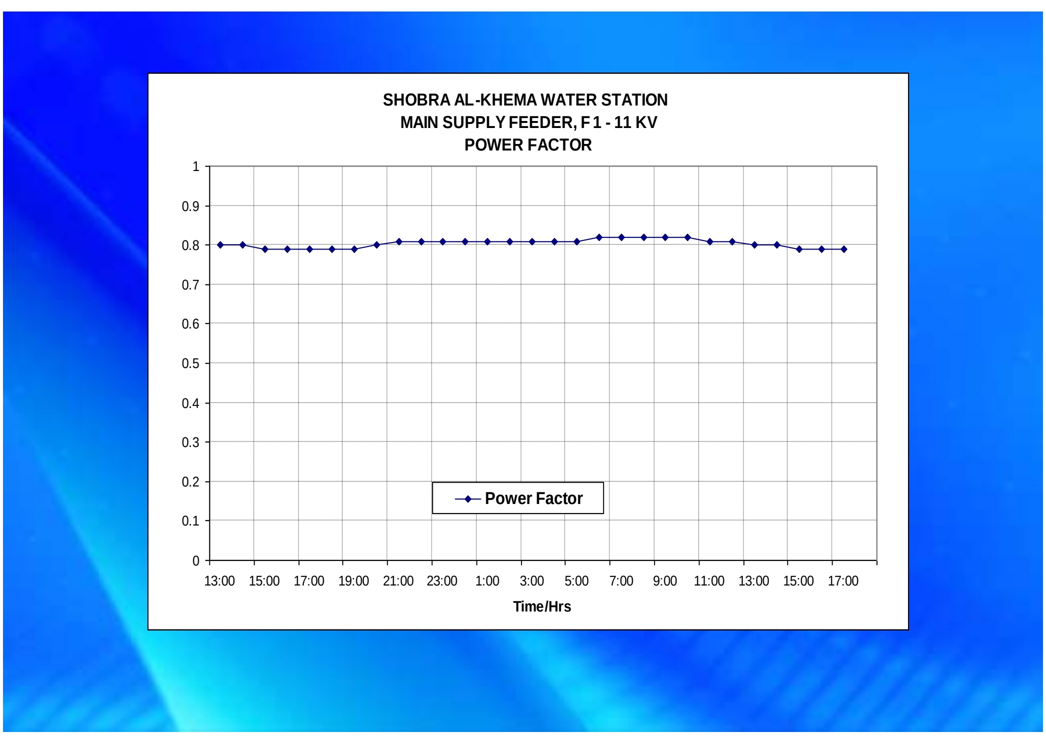
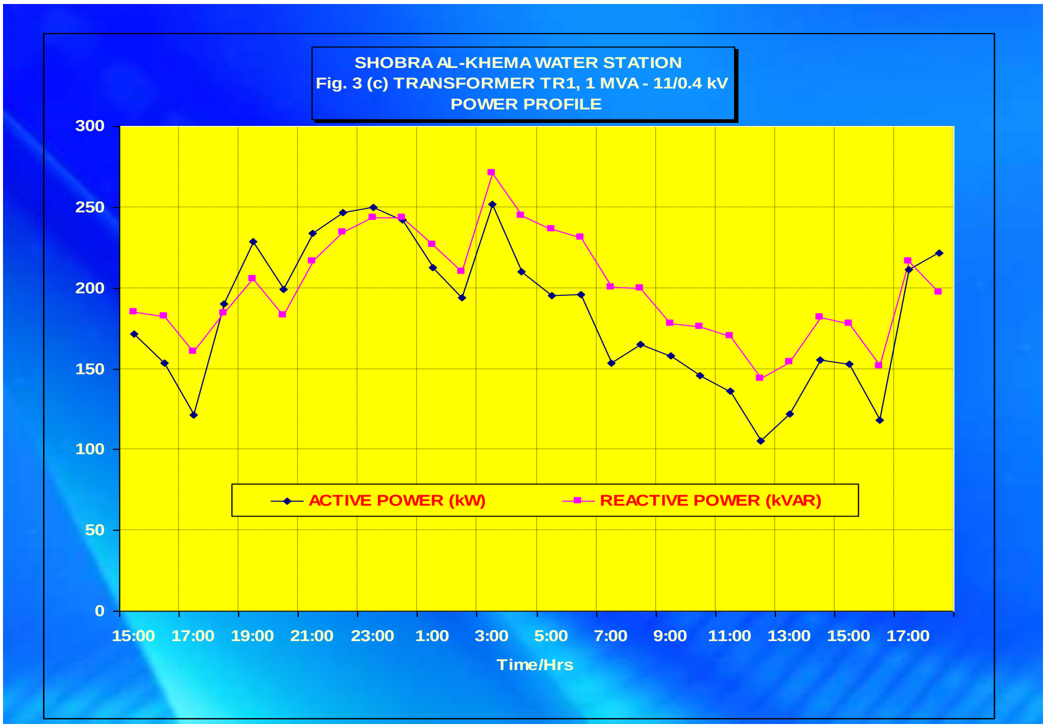
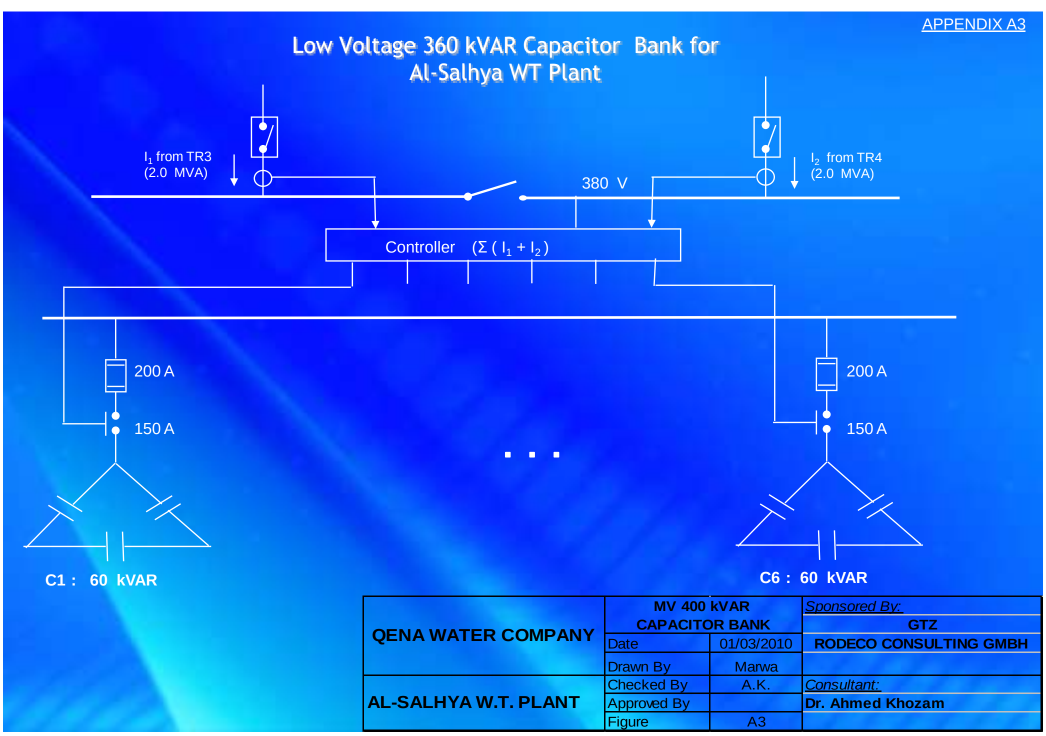


Figure 2
F1
From Basatin S.S.
1250 A
1250 A
From Al-Haram S.S.
F2
1250 A
11 kV
TR5 , 1.5 MVA
11/ 0.4 kV
TR6, 1.5 MVA
11/ 0.4 kV
1250 A
380 V
200 200 315 315 315 200 kW
RAW WATER . PUMPS
GTZ
PN 2006.2063.3; VN 81087234
RODECO CONSULTING GMBH
QENA WT COMPANY
AL-SHIEKH HUSEIN (RAW WATER) INTAKE
SINGLE LINE DIAGRAM
Consultant: Dr. Ahmed Khozam

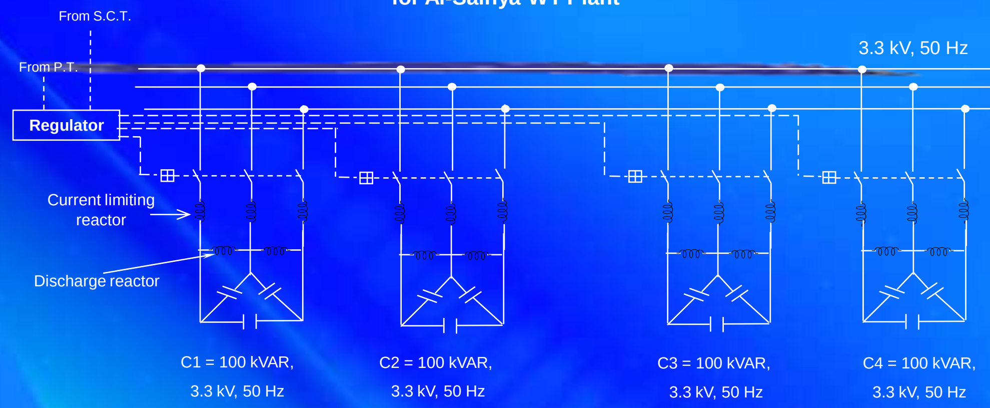

SHOBRA AL-KHEMA WATER STATION
MAIN SUPPLY FEEDER, F 1 - 11 KV
POWER FACTOR
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Power Factor
13:00 15:00 17:00 19:00 21:00 23:00 1:00 3:00 5:00 7:00 9:00 11:00 13:00 15:00 17:00
Time/Hrs


SHOBRA AL-KHEMA WATER STATION
Fig. 3 (c) TRANSFORMER TR1, 1 MVA - 11/0.4 kV
POWER PROFILE
300
250
200
150
100
50
0
15:00 17:00 19:00 21:00 23:00 1:00 3:00 5:00 7:00 9:00 11:00 13:00 15:00 17:00
Time/Hrs
ACTIVE POWER (kW)
REACTIVE POWER (kVAR)


APPENDIX A3
Low Voltage 360 kVAR Capacitor Bank for
Al-Salhya WT Plant
I1 from TR3
(2.0 MVA)
I2 from TR4
(2.0 MVA)
380 V
Controller (Σ (I1 + I2)
200 A
150 A
200 A
150 A
C1 : 60 kVAR
C6 : 60 kVAR
QENA WATER COMPANY
AL-SALHYA W.T. PLANT
MV 400 kVAR
CAPACITOR BANK
Date 01/03/2010
Drawn By Marwa
Checked By A.K.
Approved By
Figure A3
Sponsored By:
GTZ
RODECO CONSULTING GMBH
Consultant:
Dr. Ahmed Khozam

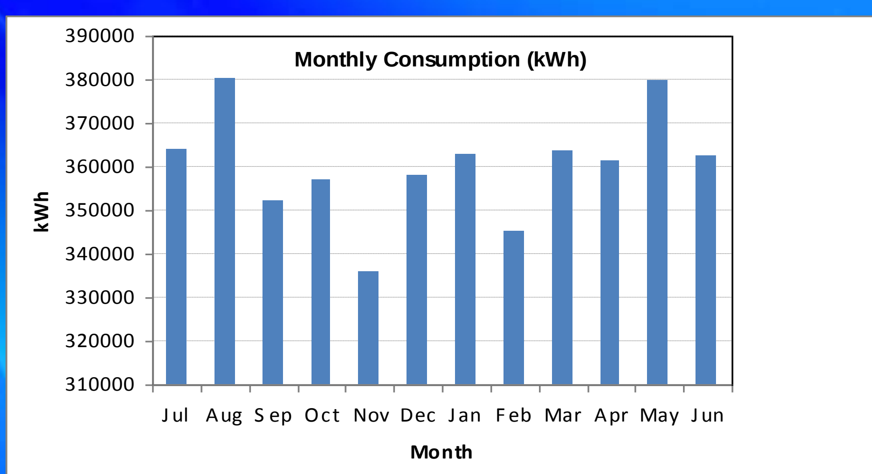
APPENDIX A2

Medium Voltage 400 kVAR Capacitor Bank
for Al-Salhya WT Plant



QENA WATER COMPANY	400 kVAR, 3.3 kV, 50 Hz CAPACITOR BANK		*Sponsored By:* GTZ RODECO CONSULTING GMBH
	Date	01/03/2010	
	Drawn By	Marwa	
AL-SALHYA W.T. PLANT	Checked By	A.K.	*Consultant:*
	Approved By		Dr. Ahmed Khozam
	Figure	A2	

ALSALHYA MONTHLY CONSUMPTION

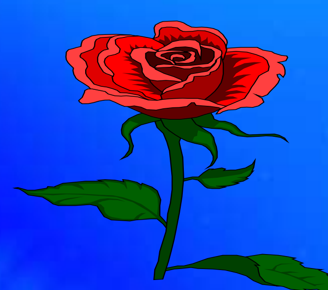


WHAT IS THE SCOPE OF ACTIVITIES FOR PF IMPROVEMENT STUDY ?

- **PHASE 1**
  - Data Collecttion
  - Measurements
  - Sizing and Location of Equipment
  - Specifications of equipment and procurement documents
  - Report

- **PHASE 2**
  - Installation
  - Commissioning and Startup
  - Monitoring & Verification.

THANK YOU



CAPACITORS

What was left out ?

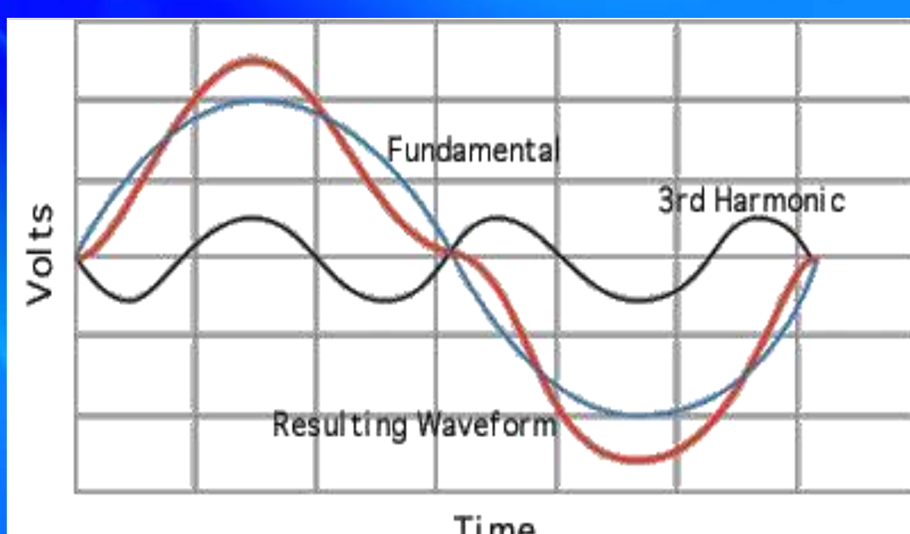
- **The Problem of Harmonics**
  - ❖ What are Harmonics?
  - ❖ What is meant by Non-linear Loads?
  - ❖ Examples of Harmonic Generators
  - ❖ Can capacitors be used in Non-Sinusoidal Environment?

The Problem of Harmonics

Definition:

Harmonics are integral multiples of some fundamental frequency that, when added together, result in a distorted waveform.

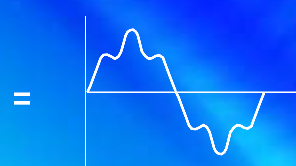
What are Harmonics ?



What are Harmonics?

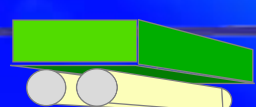
$f(x) = \sin(x)$ $\qquad$ $f(x) = \frac{\sin(5x)}{5}$

The resulting wave shows a strong departure from the smooth waves comprising it:

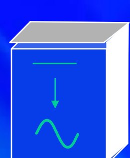


$f(x) = \sin(x) + \frac{\sin(5x)}{5}$

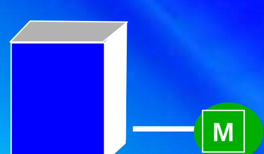
Common sources of Harmonics



Lighting ballasts



UPS systems



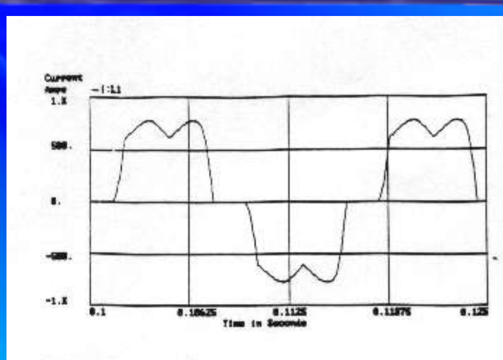
AC and DC drives

What kind of Power Quality Effects?

- Harmonic Distortion
  - AFDs, DC Drives, UPSs, DC power supplies (computers, duplicators, fax's) *will* cause current (and voltage) harmonics
    - Single phase – 3rd, 6th, etc (triplens) can cause transformer neutral conductor overheating
    - Three phase – 5th, 7th, 11th, 13th, etc can cause equipment malfunctions
    - Big questions – "How much?" and "How much is too much?"

AC drives and Harmonics

Typical 6-step converter waveform:



Harmonic Content

I_5 = 22.5%

I_7 = 9.38%

I_{11} = 6.10%

I_{13} = 4.06%

I_{17} = 2.26%

I_{19} = 1.77%

I_{23} = 1.12%

I_{25} = 0.86%

Recommended limits - IEEE 519

The Institute of Electrical and Electronics Engineers (IEEE) has set recommended limits on both current and voltage distortion in IEEE 519-1992.

Voltage distortion limits (@ low-voltage bus):

Application class	THD (voltage)
Special system	3 %
General system	5 %
Dedicated system	10 %

USEFUL FORMULAS

- **Losses Reduction :**

$$\% \text{ L.R.} = 100 - 100 \left(\frac{\text{Original PF}}{\text{Improved PF}} \right)^2$$

Recommended limits - IEEE 519

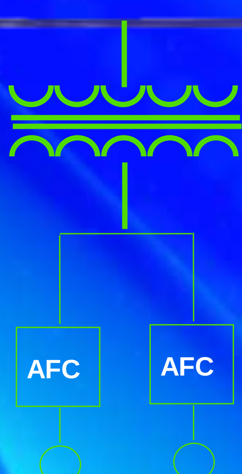
MAXIMUM HARMONIC CURRENT DISTORTION
in percent of I_L

	Individual harmonic number (odd harmonics)				
I_{sc}/I_L	<11	11<h<17	17<h<23	23<h<35	TDD
<20	4.0	2.0	1.5	0.6	5.0
20-50	7.0	3.5	2.5	1.0	8.0
50-100	10.0	4.5	4.0	1.5	12.0
100-1000	12.0	5.5	5.0	2.0	15.0
>1000	15.0	7.0	6.0	2.5	20.0

I_{sc}: Maximum short-circuit current at the Point of Common Coupling (PCC).

I_L: Maximum demand load current (fundamental) at the PCC.

Harmonics and transformers



- Many transformers are rated by "K factor" which simply describes their ability to withstand harmonics.
- Transformers may also be derated to compensate for the additional heating caused by harmonics.
- Improved transformer designs have also been developed, with oversized neutral busses, special cores, and specially designed coils.

Attenuation of Harmonics

- Passive Filters

Method:	Provide a low-impedance path to ground for the harmonic frequencies.
Benefits:	May be tuned to a frequency between two prevalent harmonics so as to help attenuate both.
Concerns:	Tuning the filters may be a labor-intensive process.
	Filters are difficult to size, because they offer a path for harmonics from any source.
	Quite sensitive to any future system changes.

Attenuation of Harmonics

- Inductive Reactance

Method:	Add a line reactor or isolation transformer to attenuate harmonics.
Benefits:	Low cost.
	Technically simple.
Concerns:	Tends to offer reductions in only higher order harmonics. Has little effect on the 5^{th} and 7^{th} harmonics.
	Because of the associated voltage drop, there are limits to the amount of reactance that may be added.

Attenuation of Harmonics

- Active Filters

Method:	Inject equal and opposite harmonics onto the power system to cancel those generated by other equipment.
Benefits:	Have proven very effective in reducing harmonics well below required levels.
Concerns:	The high performance inverter required for the harmonic injection is costly.
	Power transistors are exposed to conditions of the line, so reliability may be a problem.

فرص تحسين
كفاءة استخدام الطاقة
بشركات مياه الشرب والصرف الصحي

١

مذكرة التفاهم بين مشروع تحسين كفاءة الطاقة والشركة القابضة لمياه الشرب والصرف الصحي

- تم توقيع مذكرة تفاهم بين الطرفين بهدف تحسين كفاءة استخدام الطاقة وخفض تكلفتها لدي الشركات التابعة للشركة القابضة لمياه الشرب والصرف الصحي.

- تشمل المذكرة أربعة مجالات هي:

أ. تنفيذ مشروعات لتحسين كفاءة الطاقة ذات عائد سريع وتشمل مشروعات تحسين معامل القدرة وإستخدام مغيرات السرعة وادارة الطلب علي الطاقة والإضاءة عالية الكفاءة.
ب. انشاء نظام لمؤشرات القياس لكفاءة استخدام الطاقة بالشركات التابعة للشركة القابضة.
ج. دراسة الجدوى الفنية والاقتصادية لبعض تكنولوجيات ترشيد الطاقة وإمكانيات توليد الطاقة من محطات المعالجة وشبكات المياه والصرف
د. التدريب وبناء القدرات.

٢

مؤشرات القياس لكفاءة الطاقة:

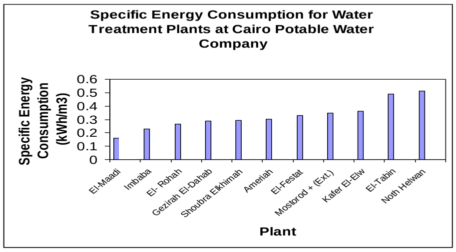
- هي مقارنة لمعدلات استهلاك الطاقة الحالية مع معدلات مرجعية (Benchmark)أو أفضل معدلات اداء (Best Practice) بغرض تقييم فرص تحسين كفاءة استخدام الطاقة.
- من خلال برنامج لمؤشرات القياس يمكن تحديد أهداف عملية قابلة للتطبيق في اطار زمني محدد.
- بناءا علي الخبرة السابقة وجد أن هناك دائما امكانية لرفع كفاءة استخدام الطاقة في حدود ٢٠ - ٣٠%

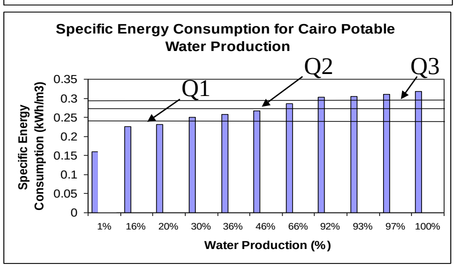
٣

برنامج مؤشرات القياس لكفاءة الطاقة

٤

مثال لمؤشرات القياس بشركة مياه القاهرة الكبري





Q1. هو أقل معدل استهلاك نوعي للطاقة لـ٢٥% من المياه المنتجة علي مستوي الشركة.

Q2. هو أقل معدل استهلاك نوعي للطاقة ٥٠% من كمية المياه المنتجه علي مستوي الشركة.

Q3. هو أقل معدل استهلاك نوعي للطاقة لـ٧٥% من كمية المياه المنتجة علي مستوي الشركة

المحطات ذات معدل استهلاك نوعي اعلي من Q3تمثل محطات ذات كفاءة منخفضة ويستلزم اجراء دراسة لمراجعات الطاقة بتلك المحطات لمعرفة سبب تدني كفائتها.

٥

فرص تحسين كفاءة استخدام الطاقة في شركات مياه الشرب والصرف الصحي

تعتبر عمليات تنقية مياه الشرب معالجة والصرف الصحي احدى العمليات كثيفة الاستهلاك للطاقة حيث تمثل تكلفة الطاقة في حدود ٥٠% من تكلفة انتاج او معالجة ١ متر٣ من المياه.

يمكن تقسيم فرص تحسين كفاءة الطاقة في هذه الشركات الى ثلاث مستويات:

- الفرص منخفضة التكاليف وذات العائد السريع
- فرص متوسطة التكاليف وذات عائد متوسط
- فرص عالية التكاليف

٦

أولا فرص منخفضة التكاليف

تتمثل هذه الفرص في اجراءات الصيانة والتشغيل وتشمل

- خفض التسريب في المحطات والشبكات
- ادارة الاحمال لضمان عمل الطلمبات عند اعلي كفاءة مما يستلزم اغلاق أو تشغيل الطلمبات الموجودة علي التوازي للتناسب مع معدل السريان والضغط المطلوبين.
- التأكد من عدم وجود حيود Misalignment بين محوري الطلمبة والمحرك الكهربائي
- مراجعة الخلوصات الداخلية بين اجراء الطلمبات .
- خرط ريش الطلمبات Trimming أو استبدالها باخري اصغر في حالة وجود طلمبات ذات سعر أكبر من السعة المطلوبة.
- استخدام المولدات الاحتياطية لتخفيض الاحمال في أوقات الذروة.
- تكسية اسطح وعاء الطلمبة Volute لخفض فواقد الاحتكاك.

٧

فرص متوسطة التكاليف ذات جدوي اقتصادية مرتفعة تشمل تلك الفرص الاتي:

- تحسين معامل القدرة حتي ٩٥ % بما يسمح ليس فقط بتفادي غرامة معامل القدرة بل الحصول علي وفر اضافي يعادل ٠.٥ % لكل ١% زيادة في معامل القدرة عن ٩٢% وحتي ٩٥%.
- استخدام مغيرات السرعة
- استبدال الطلمبات أو عدم تناسبها مع السعة المطلوبة .
- استخدام الطلمبات المساعدة booster pumps وذلك لفصل خطوط المياه ذات الضغط المرتفع عن تلك ذات الضغط المنخفض.
- مراجعة سعات المحركات الكهربية وكفاءتها بحيث لا تزيد
- عن ٢٠% عن القدرة اللازمة للطلمبة واستبدال تلك ذات الكفاءة المتدنية خاصة التي تم لفها عدة مرات

تم تحديد عدد ١٣٥ موقع تابع للشركة القابضة تعاني من تدني في معامل القدرة

تقدر غرامة معامل القدرة في تلك المواقع ب ١٠ مليون جنيه سنويا .

تم تنفيذ مغيرات السرعة بمحطة المعالجة بدمنهور حققت وفرا قدرة ٢٢٠ الف جنيه سنويا بفترة استرداد بسيطة تعادل ٥ سنوات.

٨

فرص عالية التكاليف

علي الرغم من أن هذه المجموعة من الفرص عالية التكاليف الا انها قد تكون ذات جدوي اقتصادية مرتفعة.

- اهم تلك الفرص تشمل الاتي:

- توليد الكهرباء من الحمأة في المحطات معالجة مياه الصرف.
- توليد الكهرباء من الطاقة المفقودة في شبكات المياه عن طريق التوربينات المائية.
- استخدام طرق مرشدة للطاقة في عمليات التهوية في محطات معالجة مياه الصرف.
- التعاون للمركز القومي للتحكم فى الكهرباء باستخدام المولدات الاحتياطية لخفض الحمل الاقصي أوقات الذروة.

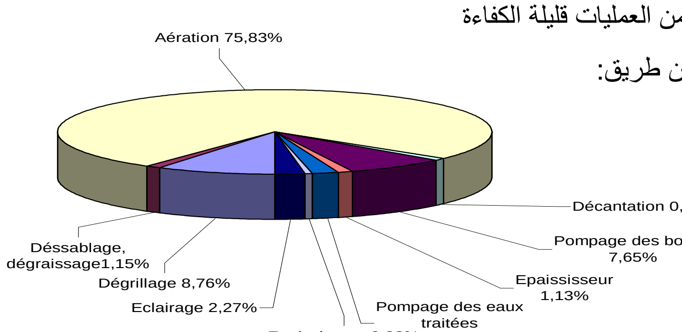
٩

استخدام طرق مرشدة للطاقة في عمليات التهوية في محطات الصرف الصحي :

- تمثل استهلاك عملية التهوية في محطات معالجة مياه الصرف الصحي حوالي ٥٠ - ٧٥ % من الطاقة المستهلكة في تلك المحطات.
- تعتبر عملية التهوية السطحية من العمليات قليلة الكفاءة
- يمكن رفع كفاءة تلك العملية عن طريق:

استخدام الفقعات المتصاعدة.

استخدام التهوية بالنفث.



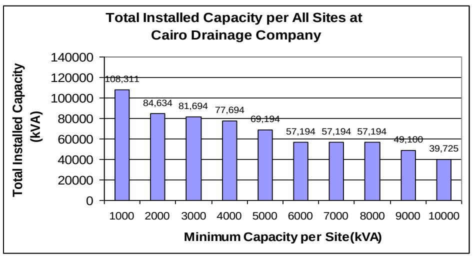
توزيع الطاقة على الاستخدامات المختلفة فى محطات معالجة مياه الصرف

١٠

استخدام المولدات الاحتياطية لخفض احمال شبكة الكهرباء وقت الذروة:

تمتلك محطات المياه والصرف الصحي قدرات عالية من وحدات التوليد الاحتياطية.

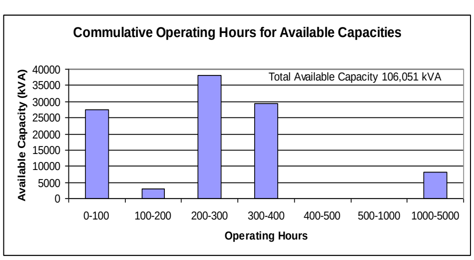
- لا يتم استخدام تلك الوحدات الا في حالات انقطاع التيار الكهربائي وهي نادرة نظرا لتغذية جميع المحطات بأكثر من مغذي وبالتالي فان معدل استخدام تلك المولدات منخفض.
- يمكن لشبكة الكهرباء استخدام تلك المولدات لخفض الحمل الاقصي بالشبكة وقت الذروة نظير دفع رسم مقابل ذلك لشركات المياه والصرف الصحي.



١١

استخدام المولدات الاحتياطية لخفض احمال شبكة الكهرباء وقت الذروة:

- يقدر العائد الذي يمكن أن يتحقق من ذلك المشروع لشركة الصرف الصحي بالقاهرة الكبري بحوالي ٦ مليون جنيه سنويا.
- لا يمثل ذلك لاستخدام اخلالا بوظيفة هذا الوحدات الاساسية كوحدات احتياطية حيث لن يزيد عدد الساعات المطلوبة عن ٤٠٠ ساعة سنويا.



١٢

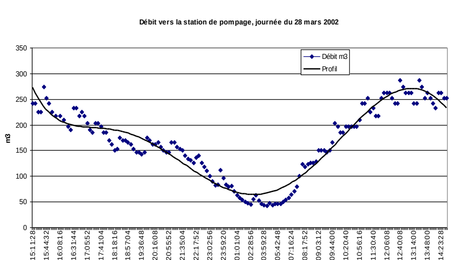
اجراءات اخري لرفع كفاءة استخدام الطاقة

- تبني برنامج لترشيد استهلاك المياه لدي المستخدمين
- تبني برنامج لإدارة الطلب علي المياه لدي المستخدمين.

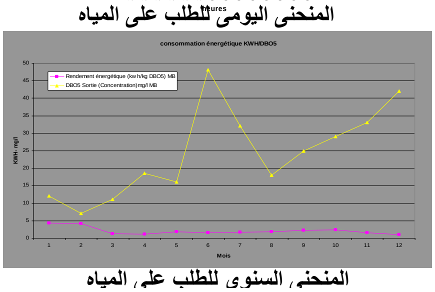
١٣

برنامج ادراة الطلب علي المياه لدي المستخدمين (DSM)

- تغيير استهلاك المياه علي مدار ساعات اليوم وكذلك علي مدار أشهر السنة.
- يرتفع استهلاك الطاقة النوعي عند ساعات الذروة وذلك لارتفاع الفواقد في الشبكات.
- انخفاض الطلب يمثل عدم كفاءة استخدام المحطات والشبكات المتاحة مما يؤدي لارتفاع التكلفة.
- يهدف برنامج ادارة الطلب علي المياه لدي المستخدمين لرفع كفاءة الاستخدام وخفض الفواقد عن طريق تحسين معامل استخدام المحطات والشبكات كذلك خفض الحمل الاقصي مما يؤدي لخفض القيمة القسط الثابت في فاتورة الكهرباء٠



المنحنى اليومى للطلب على المياه



المنحنى السنوى للطلب على المياه

١٤

تنفيذ برنامج آليات ادارة الطلب علي المياه

- تطبيق تعريفة مزدوجة للمياه (يمكن البدء بتطبيق التعريفة الافتراضية)
- تطبيق عقود خفض الاستخدام مع المستهلكين بالاتفاق مع شركات المياه
- زيادة خزانات المياه علي شبكة التوزيع لرفع كفاءة استخدام المحطات والشبكات.

١٥

كيفية تمويل مشروعات تحسين كفاءة الطاقة

- عقود الاداء مع شركات خدمات الطاقة والتى تشمل التمويل ودفع مستحقات شركات خدمات الطاقة من الوفر المتحقق
- برنامج ضمانات الاقتراض المقدم من مشروع تحسين كفاءة الطاقة
- الية التنمية النظيفة CDM والتى تقدم تمويل جزئى نظير خفض غازات الاحتباس الحرارى المكافئة للخفض فى استهلاك الطاقة

-عقود البناء والتشغيل ونقل الملكية (BOOT) وهذه العقود مناسبة لمشروعات توليد الكهرباء من الحمأة أو من الطاقة المفقودة بالشبكات

١٦

Published by:
Deutsche Gesellschaft für
Technische Zusammenarbeit (GTZ) GmbH

German Technical Cooperation
Egyptian-German Water and Wastewater Management Program (WWMP)
Corniche El Nil, Water Treatment Plant - Rod El Farag
Tel.: +202 24598405/ 411
Fax: +202 24598405/ 411 ext. 102

Commissioned by:

Federal Ministry
for Economic Cooperation
and Development

Internet:
www.wwmp-egypt.com

Printed and distributed by:
Egyptian-German Water and Wastewater Management Program (WWMP)

اعداد:
الوكالة الألمانية للتعاون الفنى (GTZ)

البرنامج المصرى الألمانى لادارة مياه الشرب و الصرف الصحى
كورنيش النيل - محطة مياه روض الفرج
ت: ٤١١ /٢٤٥٩٨٤٠٥ ٢٠٢+
ف: ٤١١ /٢٤٥٩٨٤٠٥ ٢٠٢+ داخلي ١٠٢

بتفويض من:
الوزارةالألمانية الاتحادية للتنمية و التعاون الاقتصادى

Federal Ministry
for Economic Cooperation
and Development

انترنت:
www.wwmp-egypt.com

الطباعة و التوزيع:
البرنامج المصرى الألمانى لادارة مياه الشرب و الصرف الصحى