Palestine Polytechnic University

College of Engineering

Development & Improvement of Power Distribution System for Hebron City

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Submitted to the College of Engineering

in partial fulfillment of the requirements for the

Bachelor degree in Electrical Engineering

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Palestine Polytechnic University

College of Engineering

Electrical Engineering Department

Hebron – Palestine

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Testing Committee Signature

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Chair of the Department Signature

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إهداء و شكر

الحمد لله و الصلاة و السلام على خير الانام ، نبينا محمد عليه افضل الصلاة و أتم التسليم و بعد

نشكر الله أولا وأخير على ما وفقنا إليه من إتمام دراستنا الجامعية ، ثم نتقدم بالشكر إلى القلب الحنون ، من كانت بجانبنا بكل المراحل التي مضت من حياتنا بالمعاناه وكانت شمعه تحترق لتنير دروبنا
إلى أمهاتنا الحبيبات
وإلى من علمنا أن نقف وكيف نبدأ... إلى من علمنا الصعود وعيناه تراقبنا

آبائنا الاعزاء

الى من قدم لنا الدعم و الاسناد و صبروا علينا ...

زوجاتنا و أبنائنا
لمن أمسك بيدينا وعلمنا حرفا حرفا ...سنهدي له نجاحنا اليوم إلى من كانوا سندا لنا وإلى من لهم الفضل بإرشادنا إلى طريق العلم والمعرفة إلى أساتذتنا الأفاضل، كم نحن فخورون بكم .
أصدقائنا وأحبتنا ومن سهروا معنا في مسيرتنا العلمية إلى من مدوا أياديهم البيضاء وكانوا عونا لنا في ظلام الليل
أيام جميلة قضيناها نعيشها الآن لحظة بلحظة ونشعر وكأنها شريط يمر بمخيلتنا من جديد ،لن ننساكم ماحيينا .

Chapter 1

Introduction

1.1 Background

Energy is the basic necessity for the economic development of the countries. Energy exists in different forms in nature but the most important form is the electrical energy.

The modern society is so much dependent upon the use of electrical energy that it has become a part and parcel of our life.

Studies show that the Palestinian areas are dependent on the supply of electricity to external sources. Israel provided the Palestinian areas with 88% of the available electricity, while the electricity generation station in Gaza produced 7.3% of the consumption in Palestine and 23.5% of Gaza consumption. In contrast, the amount of electricity imported from Jordan and Egypt amounted to about 4% of consumption in the Palestinian territories [1]. Consequently, the electrical system in the West Bank is currently limited to the distribution system and the beginning of the establishment of a transmission and generation systems as renewable energy.

In recent years, there has been an increase in demand for electricity in the city of Hebron, like other cities in Palestine, the electricity has been separated from many areas due to lack of electricity during the peak load period, and the feeders were loaded with maximum loads during this time, this requires to develop and improve the distribution network in the city of Hebron by analyzing the network and development of appropriate solutions.

1.2 Project General Description

Power distribution network system established mainly to provide adequate electricity supply to Customers as economically as possible with reasonable assurance of reliability. Nowadays, the Power distribution networks have grown exponentially in term of size and technology over the Past few years.

In this project we contribute solutions to the problem of limited power in Hebron City by develop and improve the performance of Hebron Medium Voltage electrical network by Electrical Transient Analysis Program (ETAP). This includes studying the best way to increase the energy of the city by adding 15 MVA of power to each of Alhusein and Umaldaleh substations and separating Halhul area with a new substation with capacity 10 MVA to achieve the best reliability of the network especially during the maximum peak load period as well as to overcome the problem of low power factor in the industrial zone especially in the morning hours.
In 2016, the difference between buying and selling energy was 35,205,771 NIS with a percentage of 19%, this includes technical losses and illegal connection to the electrical service, our project aims to reduce these losses.
Real data used in our studies to simulate the system.

1.3 Objectives

- Analysis of the Hebron city medium voltage network through the ETAP software and by using real data.
- Study the best way to increase the energy of the city so that new three points are added to Allusion (15MVA), Umaldaleh (15MVA) substations and linking the Halhul area with a special transfer substation (10MVA).
- Minimize the technical loss of the distribution network.
- Improve the power factor to more than 0.92

These objectives improve the network performance efficiency.

1.4 Motivation

Hebron City is the largest industrial city in the West Bank which is considered the most important pillars of the national economy. Therefore, the provision of high-reliability electrical power is one of the most important factors of development and investment.

Based on this importance of Hebron city, the strategic vision of Hebron Electricity Company is to follow the technological development to improve the quality of services. In the last decade, the interest in technical issues has increased. The voltage for the distribution network has been increased from 6.6kV to 11 kV for some parts of the network and all overhead lines at 33 kV have been replaced by underground cables and connecting the distribution stations with the SCADA system to control and monitor the network.

Interruption events have been occurred at the peak demand period frequently, therefore to increase the reliability of the grid must increase the capacity of feeding.

1.5 Project Methodology

- Collecting data of the distribution network.
- Creating the single line diagram for 33 kV network.
- Building the network by analyzing the network by ETAP.
- Getting the suitable and required information and statistics from the ETAP Program.
- Solving the network problems and developing its efficiency by suggesting feasible scenarios for developing and improving the network.

Chapter 2

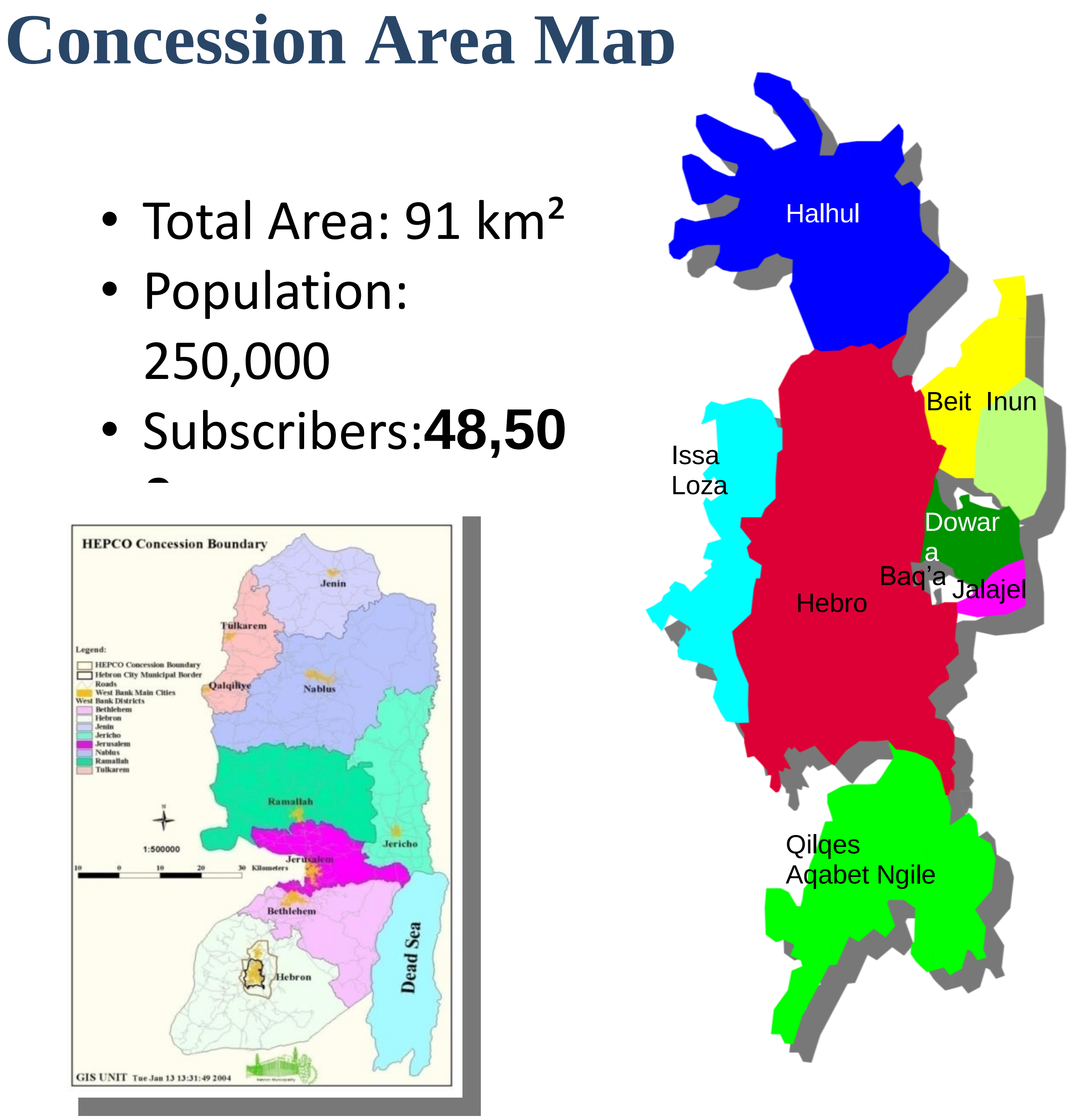
Hebron City Network

2.1 Background

Electric power has become increasingly important as a way of transmitting and transforming energy in industrial and transportation uses. The electric power system consists of three main subsystems: the generation subsystem, the transmission subsystem, and the distribution subsystem. Electricity is generated at the generation station by converting a primary source of energy to electrical energy. The voltage output of the generators is then stepped-up to appropriate transmission levels using a step-up transformer. The transmission subsystem then transmits the power close to the load centers. The voltage is then stepped-down to appropriate levels.
The distribution subsystem then transmit the power close to the consumer where the voltage is stepped-down to appropriate levels for use by a residential, industrial, or commercial customer[2].

2.2 Hebron City Network

In the early of 1973 the Municipality started to deliver the Israeli generated power through distribution network owned by the Municipality. The electric power delivered increased from 26MVA in 1994 to 104MVA in 2016 due to the normal modernization and industrialization increase.



Concession Area Map

- Total Area: 91 km²
- Population: 250,000
- Subscribers:**48,50**

Figure (2.1): Concession Area Map

The city of Hebron is supplied with electric power from a major power station of the Israel Electric Company (IEC) in Jabal al-Masjid area as shown in figure (2.2), where the voltage is transform from 161 kV to 33 kV. The distribution network as shown in figure (2.3) extends from Halhul in the north to the Aqbet Angel in the south contains 8 main stations. Most loads are connected by distribution transformers 11/0.4 kV

Source of Electricity in the South

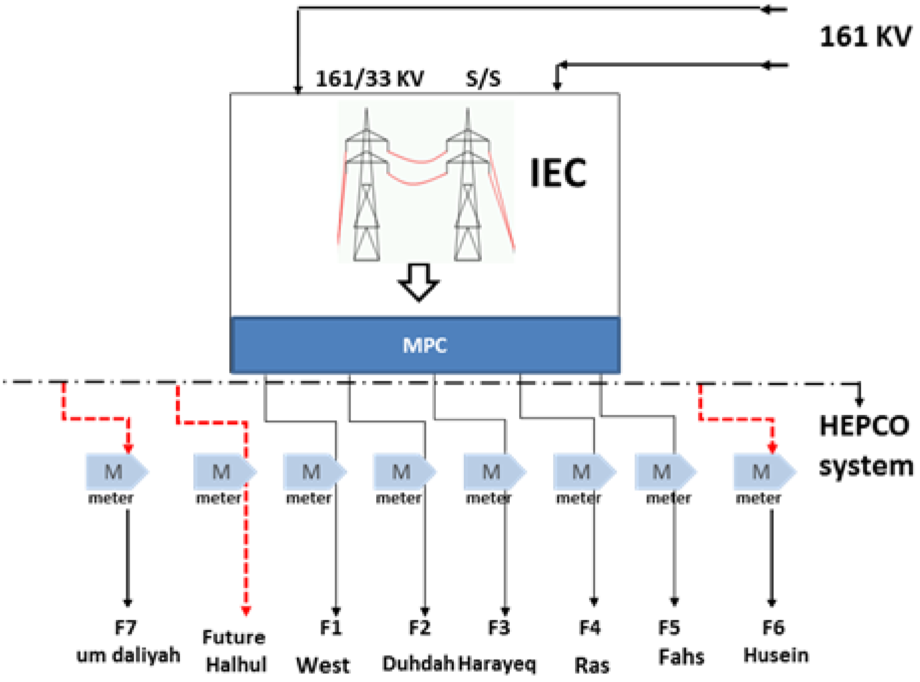


Figure (2.2): Source of Electricity in the South

The five main connecting points are controlled through Main Power Control (MPC) station as shown in figure (2.4); the station contains 14 circuit breakers and 6 couplers, to control the main lines at 33 kV and to supply energy to the main substations.

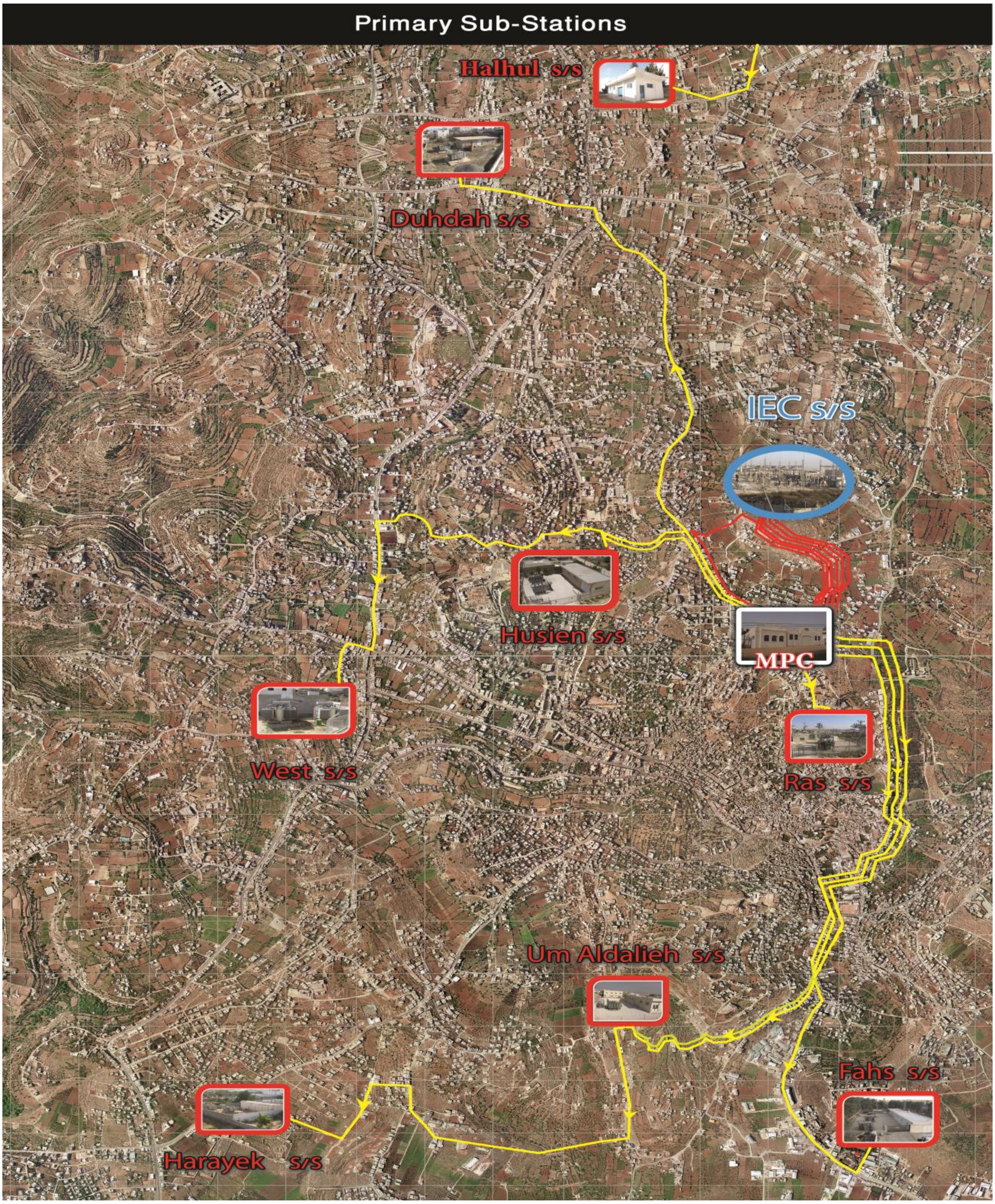


Figure (2.3): Distribution Substation for Hebron City

Figure (2.4): Main Power Control (MPC) Substation

2.3 Distribution System

Distribution systems serve as the link from the distribution substation to the customer.

This system provides the safe and reliable transfer of electric energy to various customers throughout the service territory. Typical distribution systems begin as the medium-voltage three-phase circuit, typically about 30–60 kV, and terminate at a lower secondary three- or single-phase voltage typically below 1 kV at the customer's premise, usually at the meter. Distribution feeder circuits usually consist of overhead and underground circuits in a mix of branching laterals from the station to the various customers. The circuit is designed around various requirements such as required peak load, voltage, distance to customers, and other local conditions such as terrain, visual regulations, or customer requirements. These various branching laterals can be operated in a radial configuration or as a looped configuration, where two or more parts of the feeder are connected together usually through a normally open distribution switch. High-density urban areas are often connected in a complex distribution underground network providing a highly redundant and reliable means connecting to customers. Most three-phase systems are for larger loads such as commercial or industrial customers. The three phase systems are often drawn as one line that provides the customer with 220 V, which the customer then connects to devices. This is served from a three-phase distribution feeder normally connected in a Y configuration consisting of a neutral center conductor and a conductor for each phase, typically assigned a letter A, B, or C. Single-phase customers are then connected by a small neighborhood distribution transformer connected from one of the phases to neutral.

2.3.1. Primary Substation 33/11kV

The primary purpose of an electricity distribution system is to meet the customer's demands for energy after receiving the bulk electrical energy from transmission or sub transmission substation. There are basically two major types of distribution substations:

Primary substation and distribution substation. The primary substation serves as a load center and the distribution substation interfaces to the low voltage (LV) network.

Depending on the geographical location, the distribution network can be in the form of overhead lines or underground cables. Cables are commonly used in urban areas and overhead lines are adopted for rural areas. Different network configurations are possible in order to meet the required supply reliability. Protection, control and monitoring equipment are provided to enable effective operation of the distribution network.

Hebron Electricity Network contains the following Substations:

2.3.1.1 Alduhdah Substation

The station has 3 Power Transformers33/11kV; the capacity of each transformer is 10MVAand the substation contain a number of indoor switchgears as shown in table (2.1), fig. (2.6) :(a) and (b) and specifications as follow:

Table (2.1): Alduhdah Substation Components

No. of switchgear at 33kV	5
No. of switchgear at 11kV	10
No. of couplers	1
No. of Aux.Transformer	1
Cable length(km)	3.5
Cable size	(1*300 Cu)
Insulation L1-N(kV)	18/30

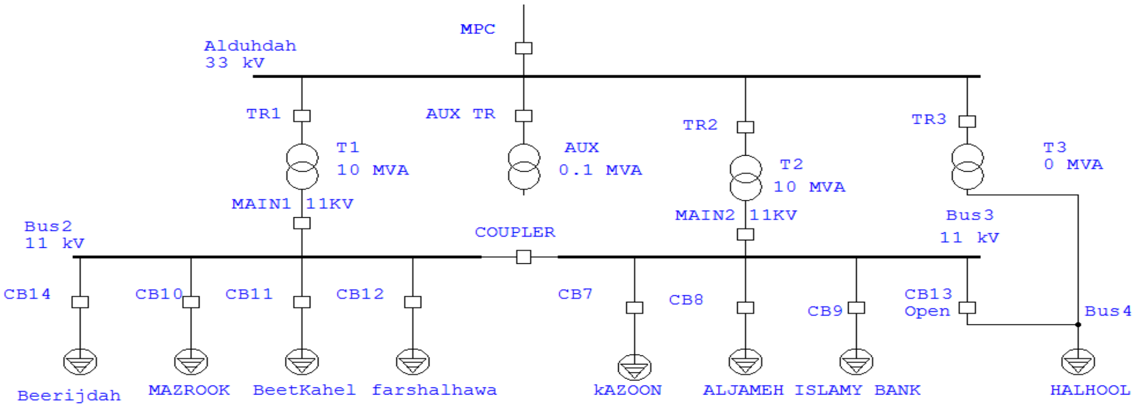


Figure (2.5): Single line diagram for Alduhdah Substation (S/S)

Figure (2.6) :(a) Switchgear in Alduhdah (S/S) (b):Power Transf. in Alduhdah (S/S)

2.3.1.2 Alfahas Substation

The station has 3 Power Transformers 33/11kV, the capacity of the first transformer is 13MVA, the other transformers are 10MVA as shown in fig.(2.8):(b) the station contains a number of indoor switchgears as shown in table (2.2) and fig.(2.8):(a) and specifications as follows:

Table (2.2): Alfahas Substation components

No. of switchgear at 33kV	5
No. of switchgear at 11kV	12
No. of couplers	2
No. of Aux.Transformer	1
Cable length(km)	3.9
Cable size	(1*300 Al)
Insulation L1-N(kV)	18/30

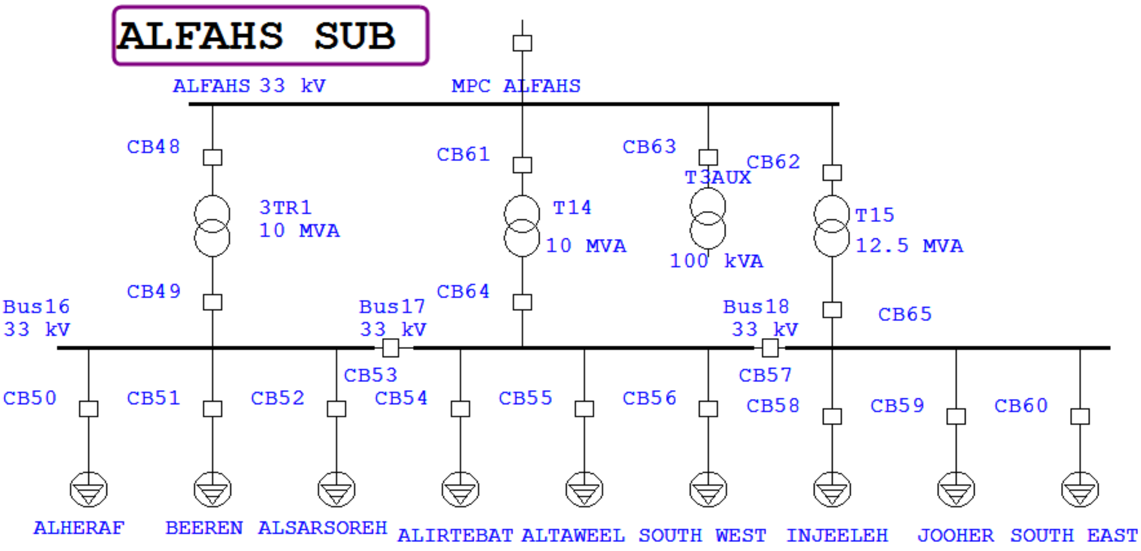


Figure (2.7): Single line diagram for Alfahas S/S

Figure (2.8): (a) Switchgear in Alfahas S/S (b): Power Transformer in Alfahas S/S

2.3.1.3 Alras Substation

The station has 2 Power Transformers 33/11kV as shown in fig. (2.10):(a) and the cooling type is Oil Natural Air Natural(ONAN); the capacity of each transformer is 10MVA, the station contains as shown in table (2.3) and fig.(2.10):(b) a number of indoor switchgears and specifications as follows:

Table (2.3): Alras Substation Components

No. of switchgear at 33kV	5
No. of switchgear at 11kV	10
No. of couplers	1
No. of Aux.Transformer	1
Cable length(km)	0.5
Cable size	(1*300 Al)
Insulation L1-N(kV)	26-45

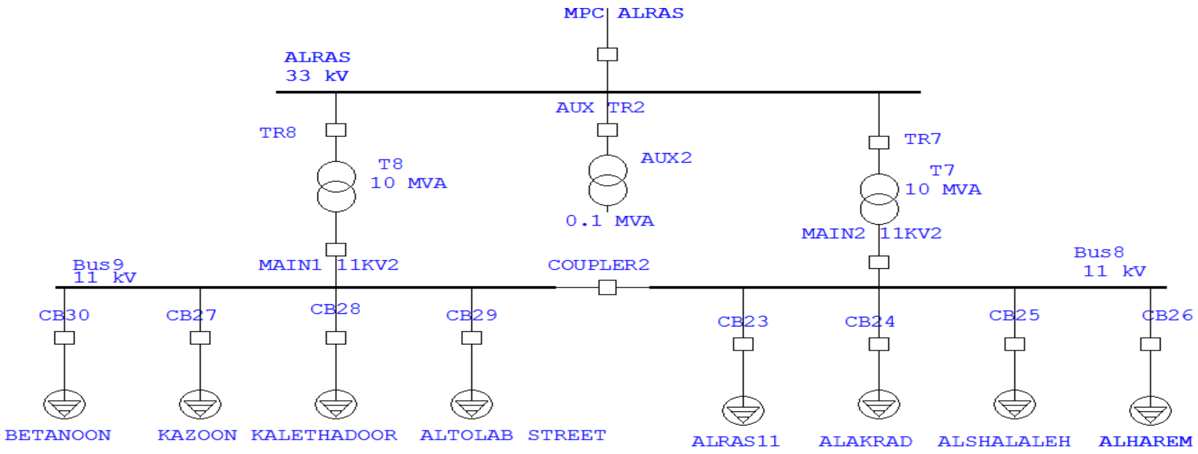


Figure (2.9): Single line diagram for Alras S/S

Figure (2.10) :(a) Power Transformer (b) Switchgear in Alras (S/S)

in Alras(S/S)

2.3.1.4 West Substations

The station has 2 Power Transformers33/11kV as shown in fig.(2.12):(b)and the cooling type is Oil Natural Air Force(ONAF); the capacity of each transformer is13MVA, the station contains as shown in table (2.4) a number of indoor switchgears as shown in (2.12):(a) as follows:

Table (2.4): West Substation Components

No. of switchgear at 33kV	6
No. of switchgear at 11kV	9
No. of couplers	1
No. of Aux.Transformer	1
Cable length(km)	3.6
Cable size	(1*300 Cu)
Insulation L1-N(kV)	26-45

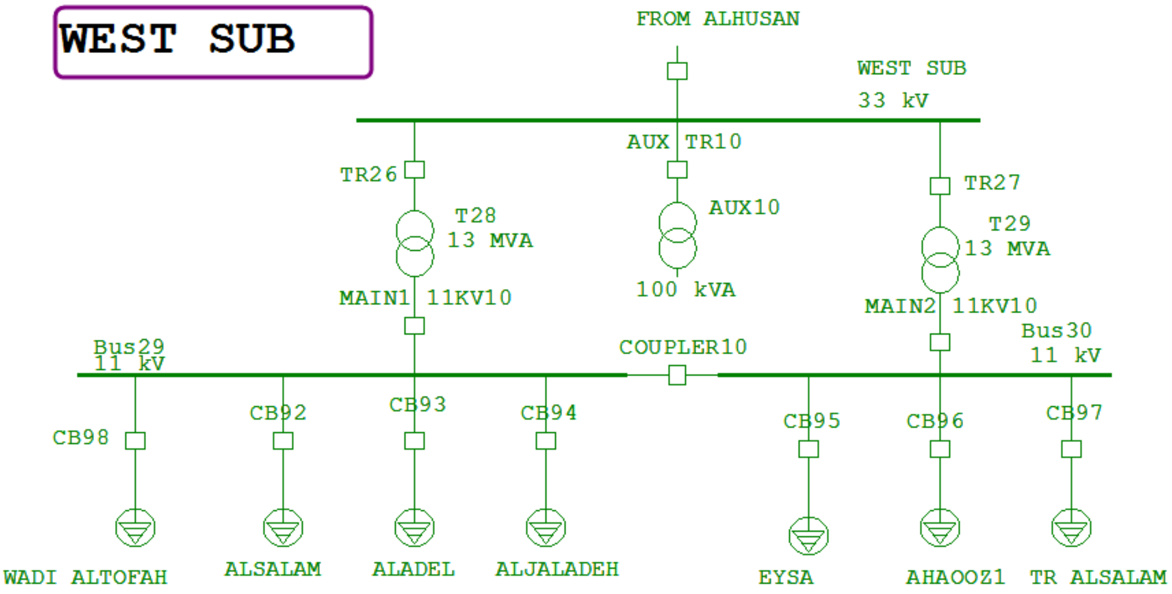


Figure (2.11): Single line diagram for West (S/S)

Figure (2.12) :(a) Switchgear in West (S/S)   (b):Power Transformer in West (S/S)

2.3.1.5 Alhusein Substation

The station has 2 Power Transformer33/11kVas shown in fig. (2.14):(b)and the cooling type ONAN; the capacity of each transformer is 10MVA, the station contains as shown in table (2.5) a number of indoor switchgears as shown in fig. (2.14):(a)as follows:

Table (2.5): Alhusein Substation Components

No. of switchgear at 33kV	4
No. of switchgear at 11kV	8
No. of couplers	1
No. of Aux.Transformer	1
Cable length(km)	1.3
Cable size	(1*300 Cu)
Insulation L1-N(kV)	26-45

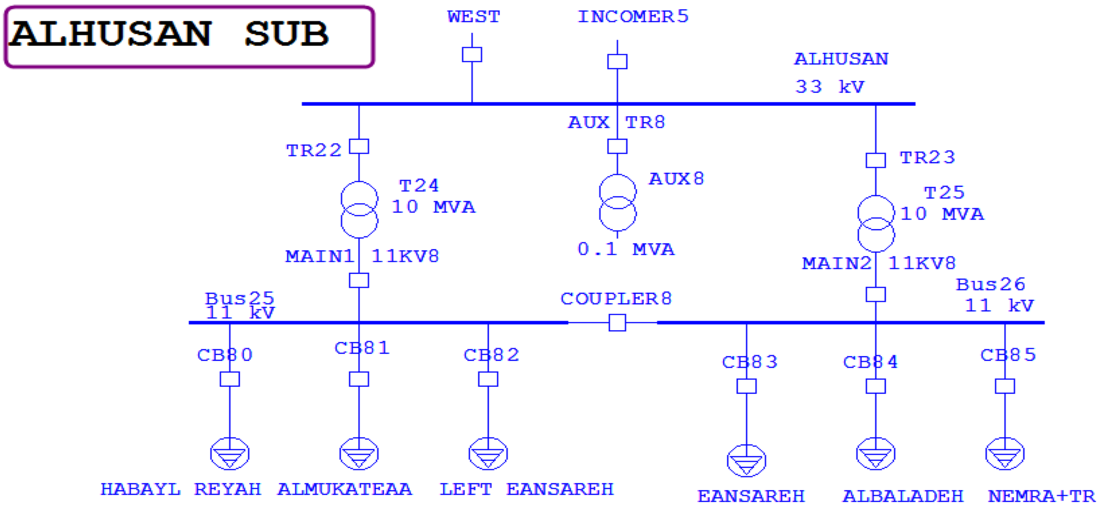


Figure (2.13): Single line diagram for Alhusein(S/S)

Figure (2.14):(a) Switchgear in Alhusein(b): Power Transformer in Alhusein (S/S) (S/S)

2.3.1.6 Umaldaleh Substation

The station has 2 Power Transformers 33/11kV; the capacity of the first transformer is 10MVA, the capacity of the second transformer is 13MVA as shown in fig.(2.16):(a), the station contains a number of indoor switchgears as shown in table(2.6) and fig.(2.16)(b) as follows:

Table (2.6): Umaldaleh Substation Components

No. of switchgear at 33kV	5
No. of switchgear at 11kV	8
No. of couplers	1
No. of Aux.Transf.	1
Cable length(km)	3.9
Cable size	(1*300 Cu)
Insulation L1-N(kV)	26-45

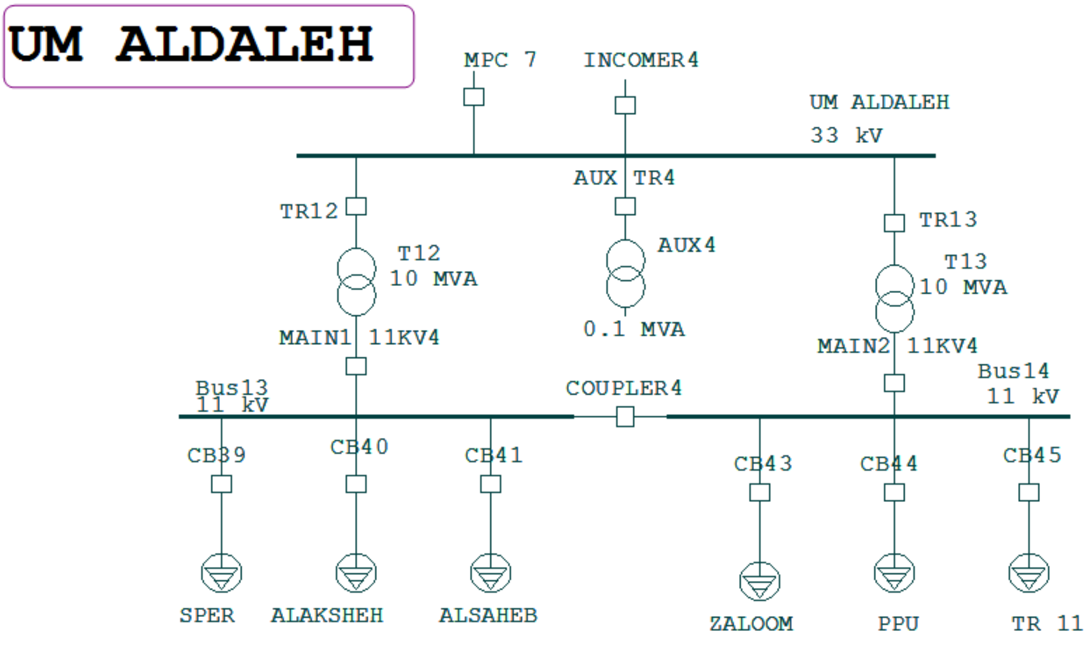


Figure (2.15): Single line diagram for Umaldaleh (S/S)

Figure (2.16)(a)Power Transf.in (b) Switchgear inUmaldaleh (S/S).

Umaldaleh (S/S).

2.3.1.7 Alhareaq Substation

The station has 2 Power Transformers 33/11kV; the capacity of the first transformer is 10MVA, the capacity to the second transformer is 13MVA as shown in fig.(2.18):(a), the station contains a number of indoor switchgears as shown in table(2.7) and fig.(2.18):(b) as follows:

Table (2.7): Alhareaq Substation Components

No. of switchgear at 33kV	4
No. of switchgear at 11kV	4
No. of couplers	1
No. of Aux.Transf.	1
Cable length(km)	6.5
Cable size	(1*300 Cu)
Insulation L1-N(kV)	26-45

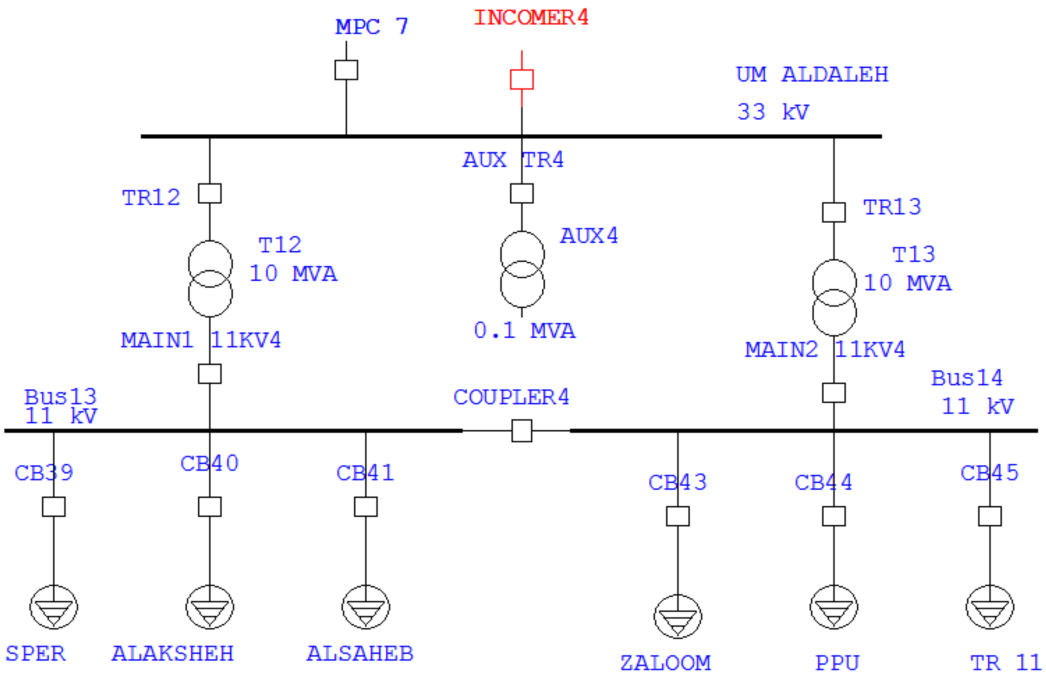


Figure (2.17): Single line diagram for Alhareaq (S/S)

Figure (2.18):(a) Power Transformer in (b) Switchgear in Alhareaq S/S

Alhareaq S/S

2.3.2 Overhead lines and Underground Cables

The Hebron electricity medium voltage network is divided into 33 kV and 11 kV network:

2.3.2.1 33kV network:

In recent years, all 33 kV lines have been changed into underground cables as shown in fig. (2.19) for several considerations, Safety and reduce the interruptions and losses on the network are the most important reasons.

Hebron electricity network uses both Copper and aluminum cables with size (1*300 mm²) and the total length about 90km

Figure (2.19): Underground Cable

2.3.2.2 11kVNetwork:

The 11kV network contains overhead lines and underground cables, Hebron electricity is working for replacing the overhead networks to underground cables.

Table (2.8): Overhead transmission line data

Name	**Cross Section(mm^2)**	**X(Ω/km)**	**R(Ω/km)**	**Current capacity(A)**
Coyote	150	0.157	0.2192	311
Dog	120	0.192	0.2733	278
Ferret	50	0.364	0.5419	161

2.3.3 Distribution Transformers

Hebron electrical network includes 619 distribution transformers as shown in table (2.9) and fig.(2.20), and these transformers have a wide range of (kVA), from (100-1000) kVA,and various rating of voltages, and this can be shown as follow:

Table (2.9): Distribution Transformers

TRANSFORMER RATED	**NUMBER**
1000	32
800	42
630	148
500	18
400	180
315	9
250	108
200	2
160	63
100	17
Total	619

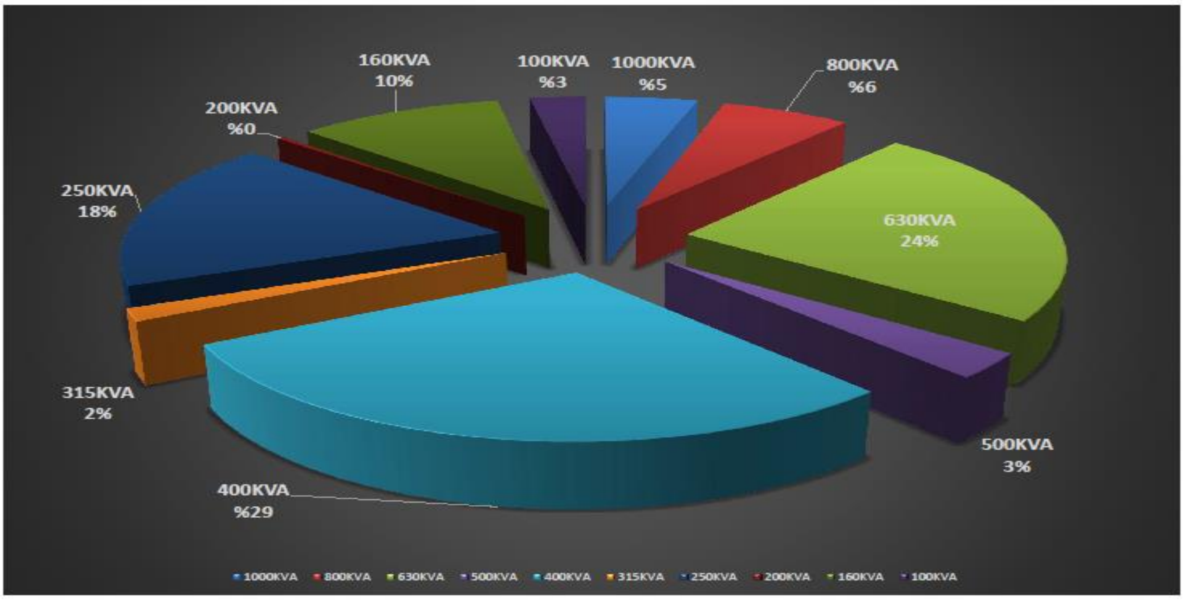


Figure (2.20): Distribution Transformers by percentage

2.3.4 Distribution Substations 11/0.4kV

Distribution substation typically operates at 2.4 – 34.5 kV voltage levels, and delivers electric energy directly to industrial and residential consumers. Distribution feeders transport power from the distribution substations to the end consumers' premises. These feeders serve a large number of premises and usually contain many branches.

At the consumers' premises, distribution transformers transform the distribution voltage to the service level voltage directly used in households and industrial plants, usually from 110 to 600 V.

Distribution Stations in Hebron Electricity provide two types of customers, special for industrial loads and general for homes and commercial loads.

Figure (2.21): Distribution Stations in Hebron Electricity

2.3.5 Ring Main Unit (RMU)

Hebron Electric used Ring Main Unit as shown in fig.(2.22) and table (2.10) to control the 11kV network and to protect distribution transformers.

General characteristics for Ring Main Unit:

Gas pressure indicator as standard.

Anti-reflex operating handles with facilities for electrical operation.

Interlocked MV cable test access (no need to remove cable terminations or use loose earthing devices).

Integral self-powered protection with TFL, adjustable curve & relay options.

Simple to follow mimic providing user-friendly operation.

Earth screened cast-resin gas module.

Range of dry type metering units.

Mechanical tripped on-fault indication.

Resin encapsulated bus bars in air bus chamber for extensible version.

Direct coupling to transformers or cable connection.

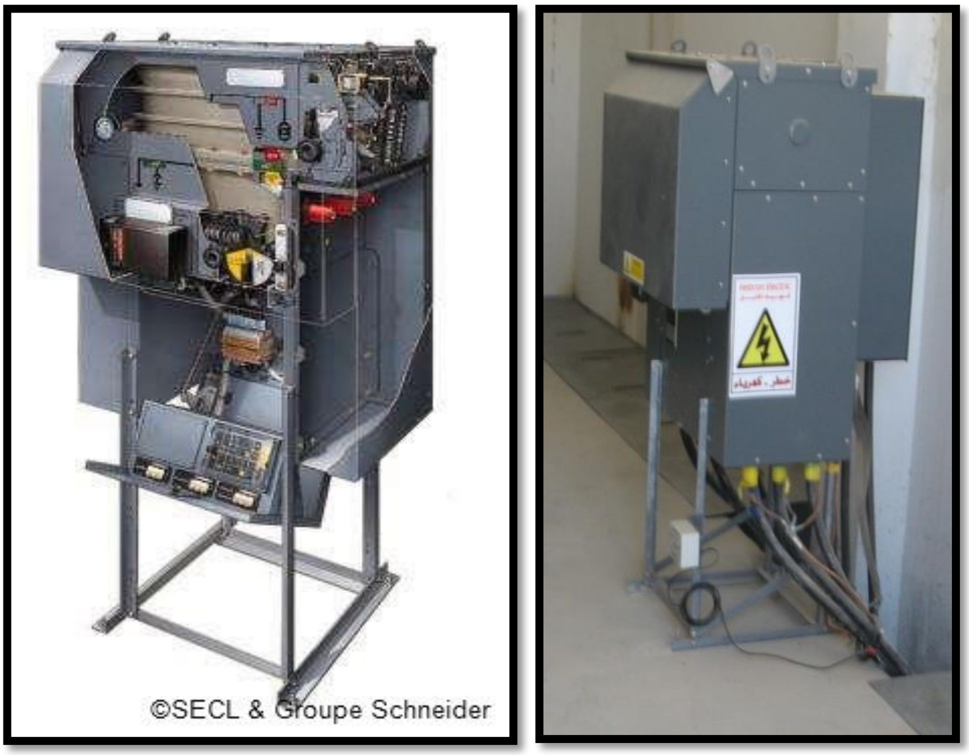


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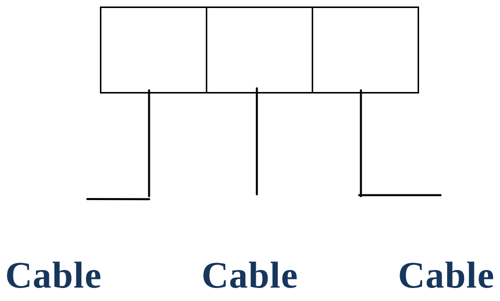
Figure (2.22) :(a) RMU – Schneider (b):RMU – connected with cable

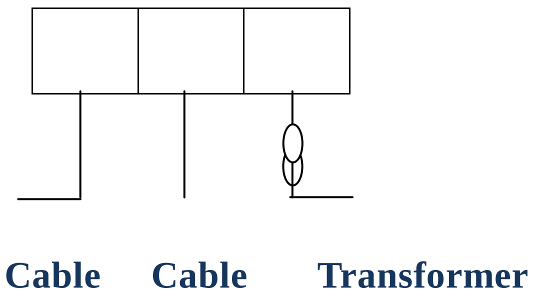
Table (2.10) Classification of the Ring Main Unit according to the number of cables or transformers

Units	Number
CCC *	**9**
CCT **	**182**
CCCT	**92**
CCTT	**11**
CCCCT	**12**
CCTTT	**1**
Total	**307**

*Example 1 for CCC



**Example 2 for CCT



Chapter 3

3.1 Loads in Hebron Electric Network

Loads of power systems are divided into industrial, Commercial, and residential. The industrial loads are composite loads, and induction motors form a high proportion of these load. These composite loads are functions of voltage and frequency and form a major pan of the system load. Commercial and residential loads consist largely of lighting, heating, and the system load. Commercial and residential loads consist largely of lighting, heating, and cooling. These loads are independent of frequency and consume negligibly small reactive power [3].

Classification of services–2016
Classification of services as shown in table (3.1) and fig.(3.1)

Table (3.1): Classification of services

Type of Service	Consumption(kWhr)
Houses	129,844,599
Commercial	90,421,074
Industrial	117,412,979
Water pumps	1,579,834
Street lighting	8,285,982
Total	347,544,468

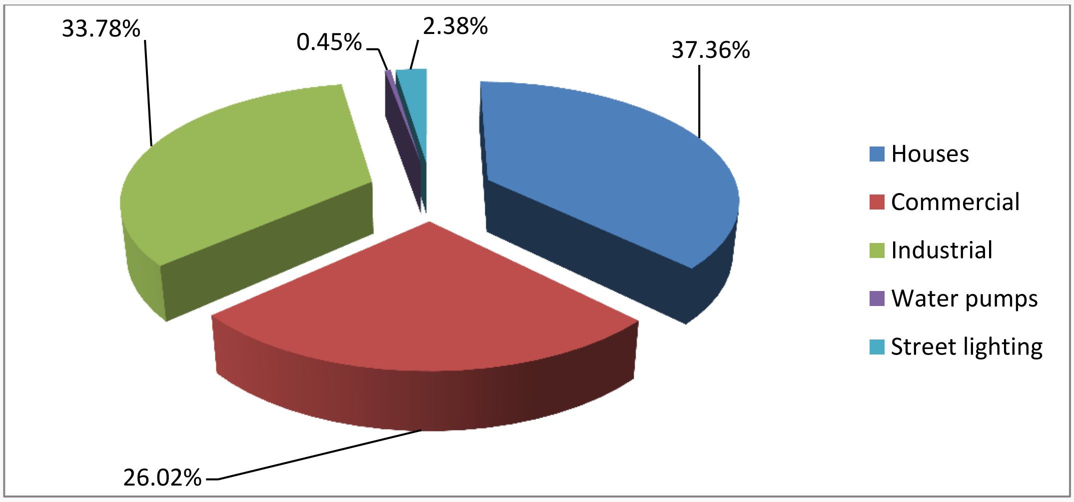


Fig.(3.1): Classification of services

3.2 Hebron Peak and Maximum and Minimum load

As many of the city's residents rely on electrical heating devices, the household loads, commercial and industrial share during the winter as shown in fig. (3.2) the composition of the maximum load of the electricity network of Hebron and has reached the maximum load for 2016 to 104. MVA [4].

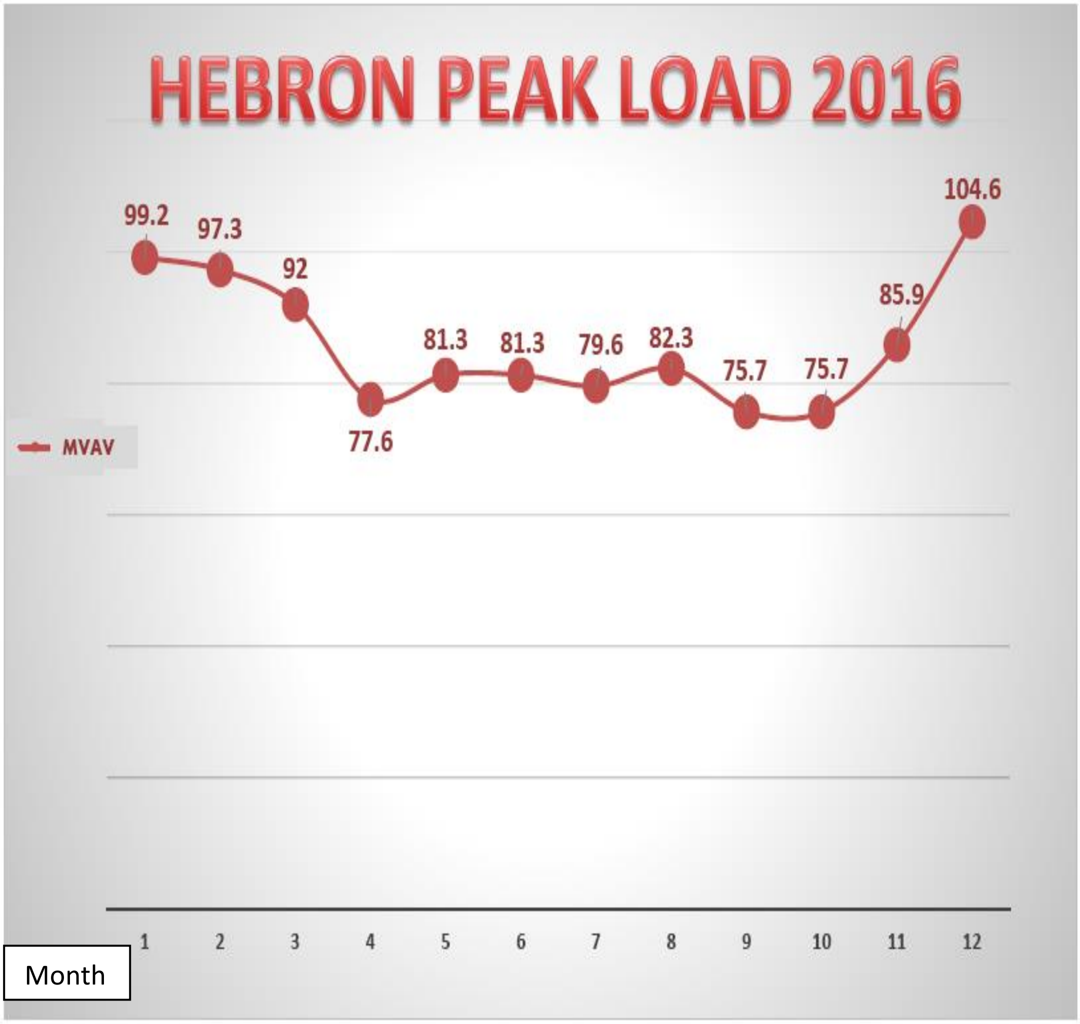


Figure (3.2): Peak Load for Hebron City – 2016

It was found that the maximum load in winter is between 2 and 3 pm as shown in fig.(3.3).

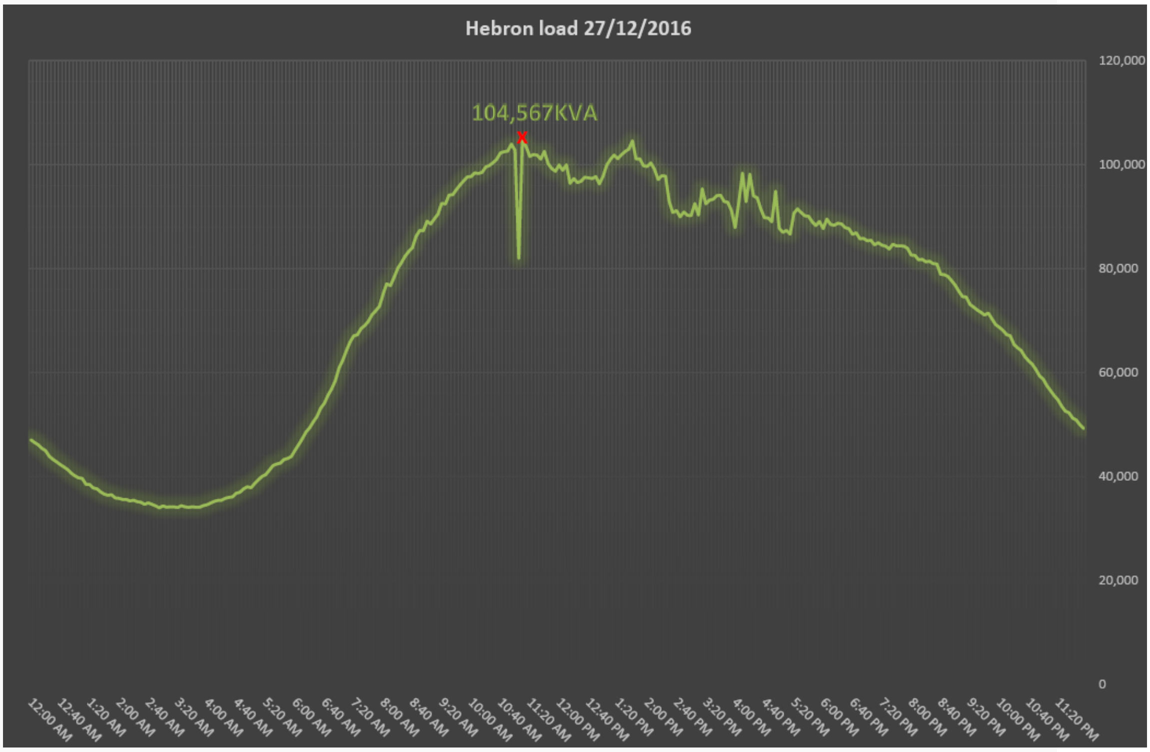


Figure (3.3): Maximum load in winter

The maximum and minimum load in 2016 as shown in fig.(3.4)

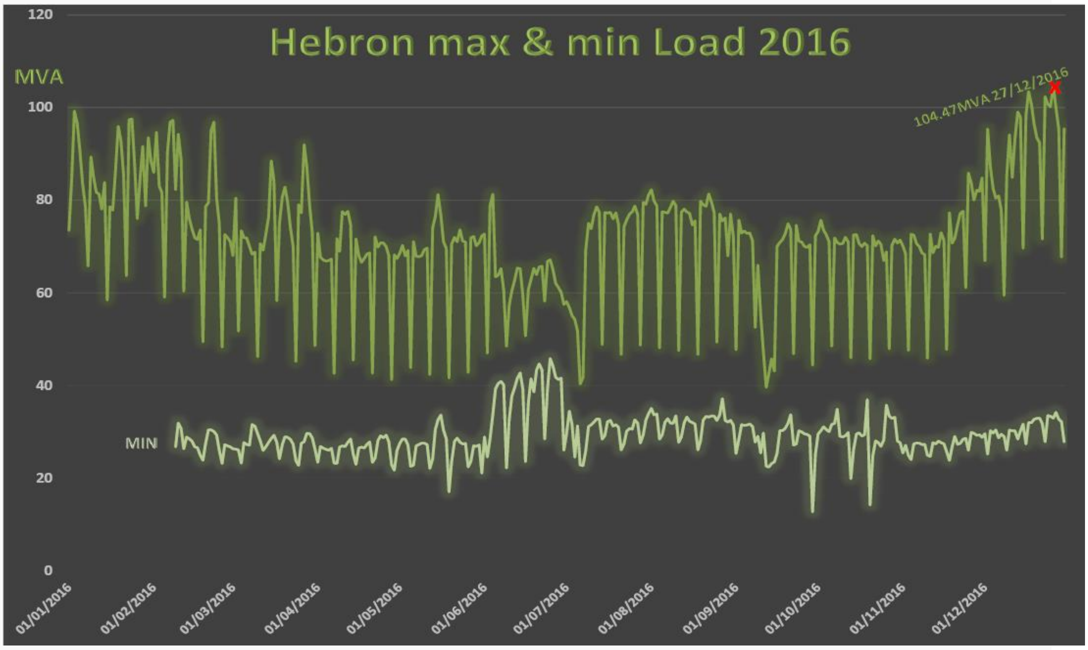


Figure (3.4):Maximum and minimum load

Power Consumptions from 2012 to 2017 as shown in fig (3.5)[5].

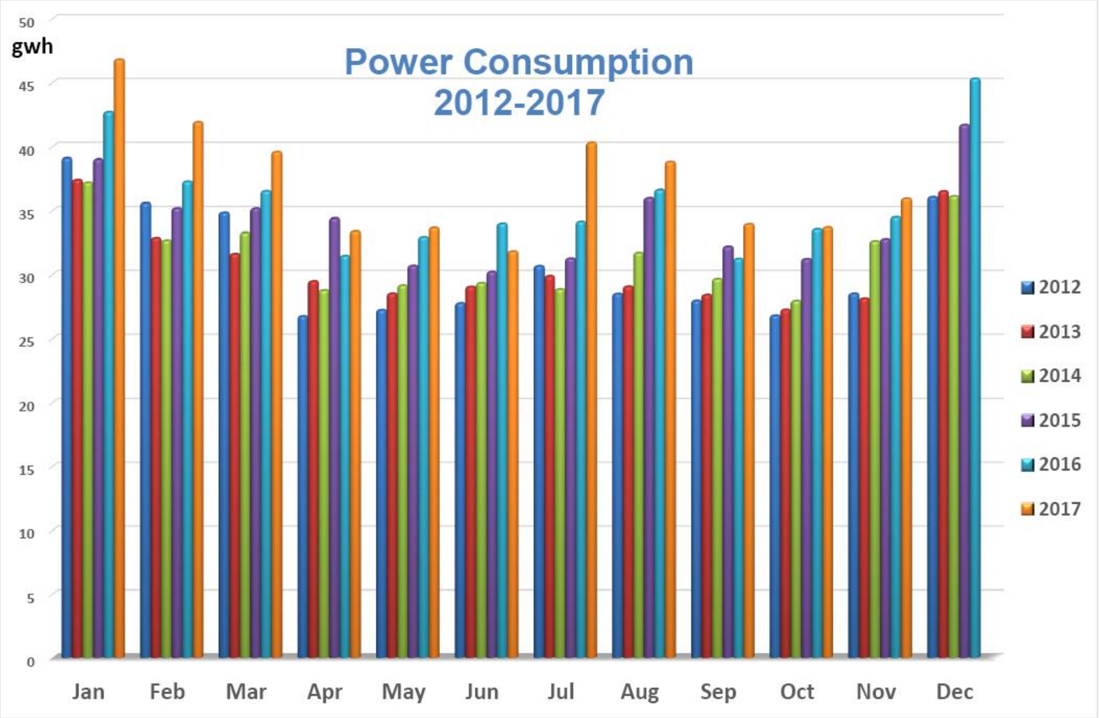


Figure (3.5): Power Consumptions from 2012 to 2017

Chapter 4

4.1 Scenarios of Development and Improvement for Hebron Distribution Network

In order to improve the performance of the Hebron electricity network, all the cables, transformers and switchgears data were collected and entered in real value on the ETAP program as shown in tables (4.1), (4.2) and Figure (4.1).

Table (4.1) Lengths of Distribution Networks

Conductors	Quantity (km)
Underground 33kV Cupper Cable 300mm²	28 km
Underground 33kV Aluminum Cable 300 mm²	8.670 km
Underground 11kV Cupper Cable 150 mm²	117.120 km
Underground 11kV Cupper Cable 120 mm²	4.295 km
Underground 11kV Aluminum Cable 95mm²	0.930 km
Underground 11kV Cupper Cable 50 mm²	5.96 km
Overhead Network 11kV	78.094 km
Total	243.069 km

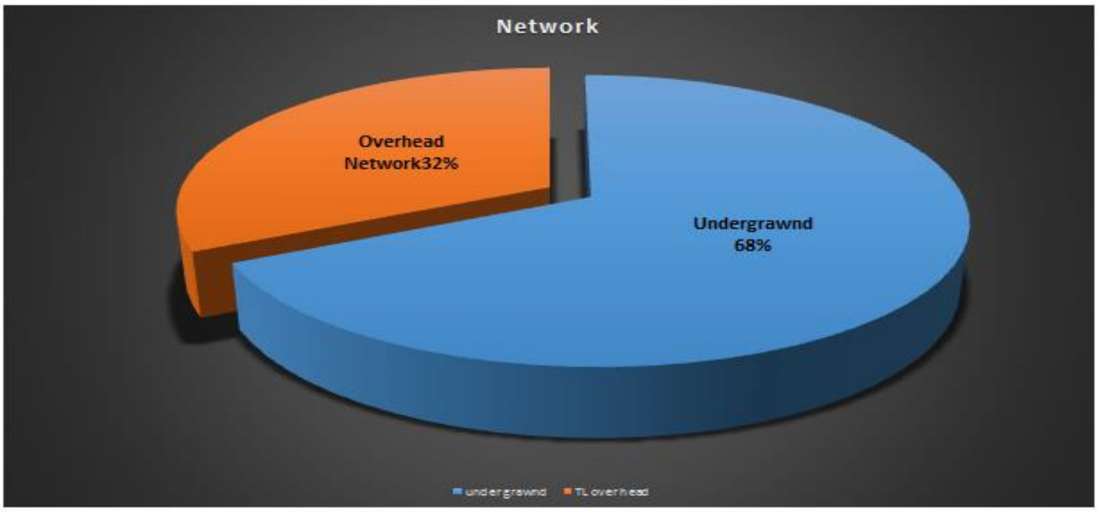


Figure: (4.1) Percentages for overhead and underground networks

Table (4.2) Numbers of Transformers

Type of Transformers	Numbers
Power Transformers	15
Distributions Transformers	619

The following Scenarios were done:

4.2 Scenario 1

4.2.1 Ring Main Electrical Power Distribution System

The drawback of radial electrical power distribution system can be overcome by introducing a ring main electrical power distribution system. Here one ring network of distributors is fed by more than one feeder. In this case if one feeder is under fault or maintenance, the ring distributor is still energized by other feeders connected to it. In this way the supply to the consumers is not affected even when any feeder becomes out of service as in figure (4.2). In addition to that the ring main system is also provided with different section isolates at different suitable points. If any fault occurs on any section, of the ring, this section can easily be isolated by opening the associated section isolators on both sides of the faulty zone transformer directly.

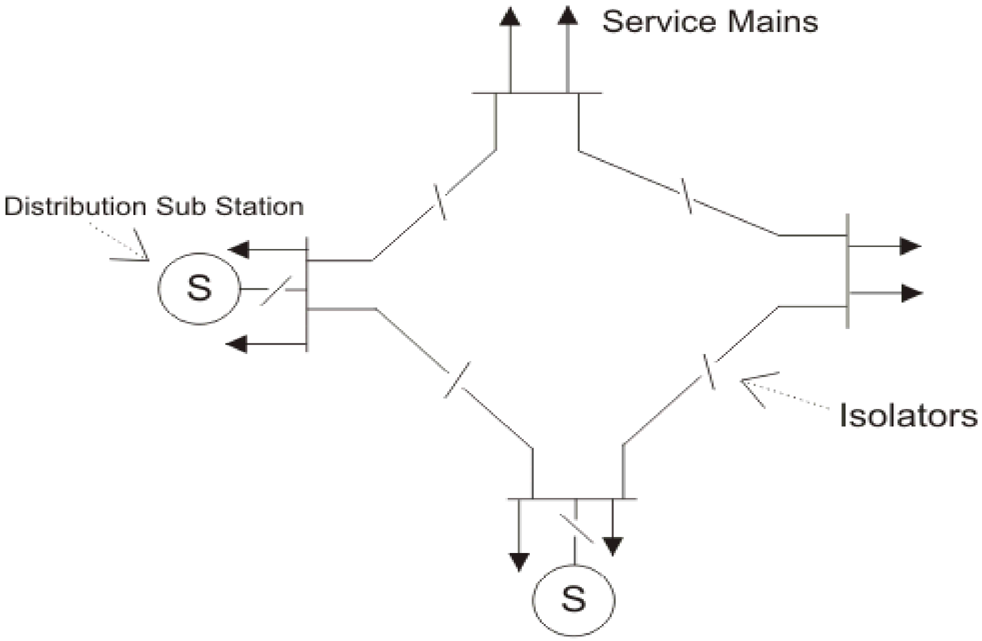


Figure (4.2): Ring Main Electrical Power Distribution System

In this way, supply to the consumers connected to the healthy zone of the ring, can easily be maintained even when one section of the ring is under shutdown. The number of feeders connected to the ring main electrical power distribution system depends upon the following factors.

Maximum Demand of the System: If it is more, then more numbers of feeders feed the ring.

Total Length of the Ring Main Distributors: It length is more, to compensate the voltage drop in the line, more feeders to be connected to the ring system.

Required Voltage Regulation: The number of feeders connected to the ring also depends upon the permissible allowable, voltage drop of the line.

The sub distributors and service mains are taken off may be via distribution transformer at different suitable points on the ring depending upon the location of the consumers. Sometimes, instead of connecting service main directly to the ring, sub distributors are also used to feed a group of service mains where direct access of ring distributor is not possible.

4.2.2 Advantages of the ring distribution system

- In ring power is supplied from both ends as compared to radial
- In case of a fault in the radial circuit the entire system goes off unlike in ring where by incase one end gets a fault the other end still keeps on supplying power
- Compared to the radial system, the voltage drop is less along the distribution line
- More subscribers can be installed to the system than the radial system
- Less voltage fluctuations can be seen at client's terminals. Voltage fluctuations in high loaded areas can be reduced using a tie line

4.2.3 Disadvantages of the ring distribution system

- Ring is very expensive requires more materials than radial.
- Radial circuit is more economical.
- High maintenance cost.
- It is not usable when the client is located at the center of the load.

4.2.4 Improving the performance of Hebron electricity network at 33 kV

After analyzing the 33kV network and studying the status of MPC station, which is a central station through which the power is received from the supplier and then distributed to the main stations within the city.

The following points show ways to improve network performance at 33 kV:

1. Due to the annual increase in energy consumption, which is 6% to 7%, the optimal distribution requires that the addition of connection points must be in the south-west of the city so that the security and reliability factors are increased to optimize with emergencies or disasters situations as in Figure (4.3).

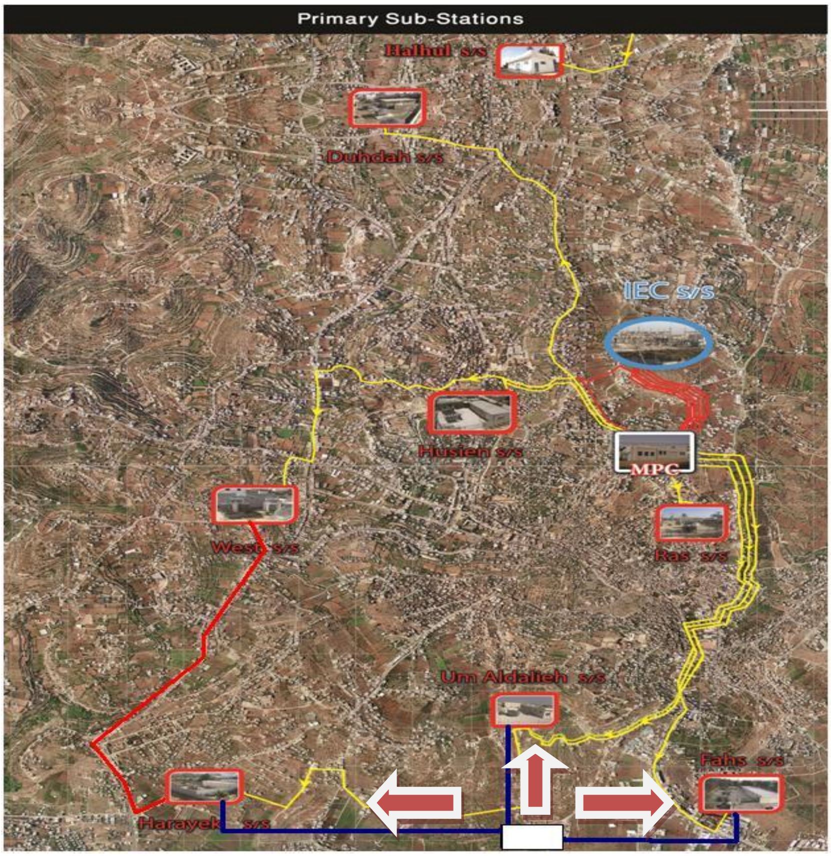


Figure (4.3): Addition of new connection points

2 – Establishing a ring System at 33 kV network by the addition of new circuit breakers and couplers, so that the efficiency of the network is increased by continuity of service when there are maintenance or interruptions at the network as shown in figure (4.4) and figure (4.5).

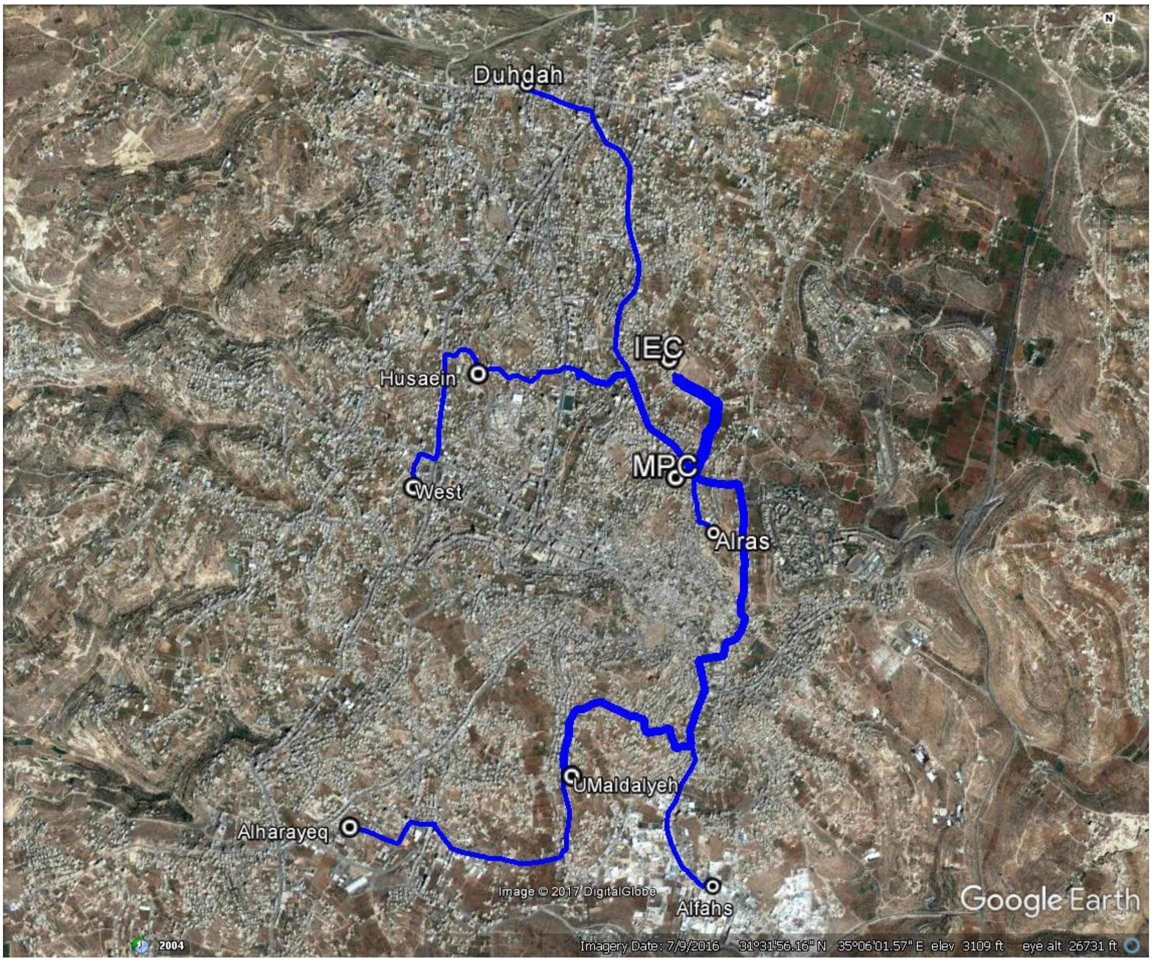


Figure (4.4):33kV Network

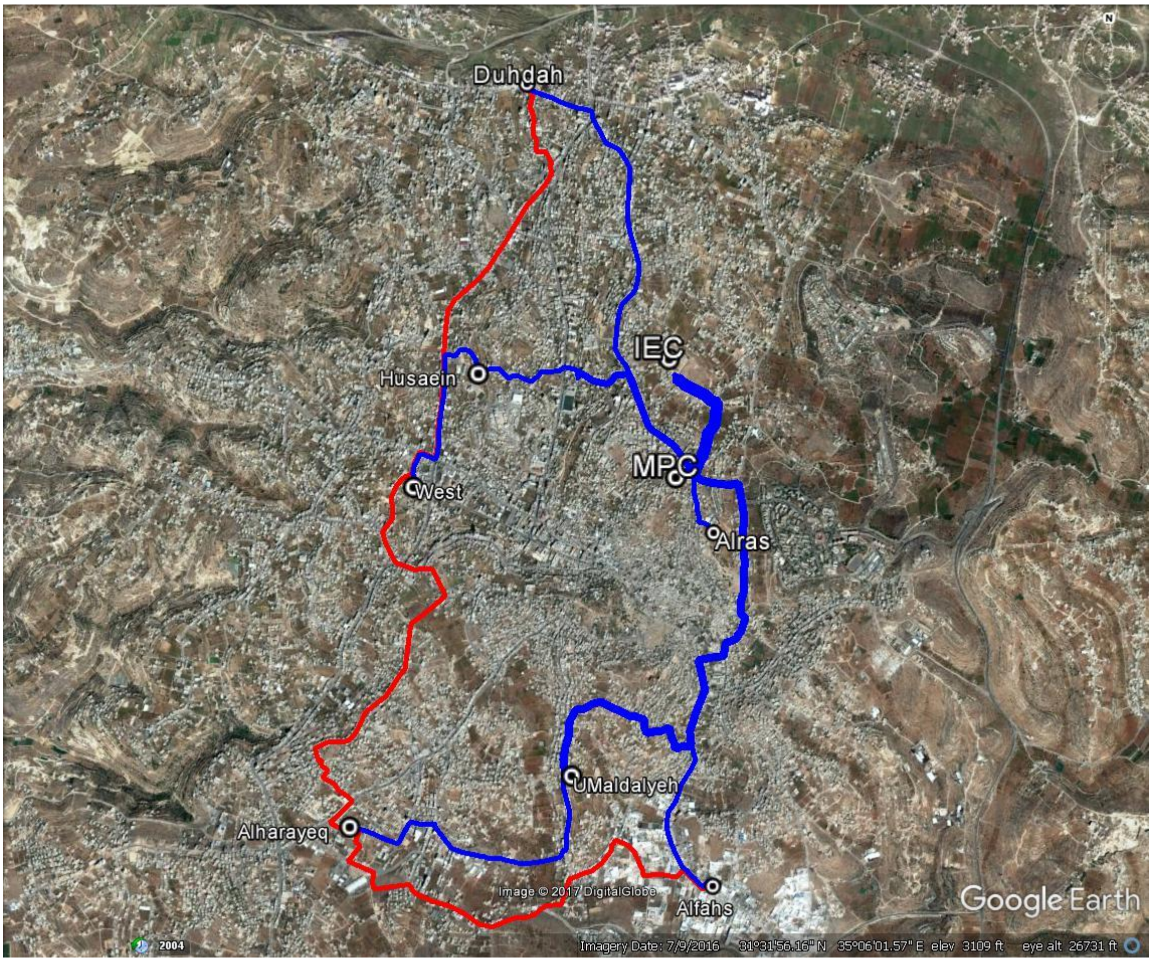


Figure (4.5): Rings connections of the 33kV network

Case Study:

Damage to the main 33 kV feeder cable which feeds the main West Station during the maximum load period.

Situation before change:

- Customers are provided from 11kV ring lines and when loads reach to maximum, the power is disconnected from some customers.
- During maintenance work on 33 kV lines and when there are peak loads on 11 kV lines, the lines may be subject to other faults, causing long-term power cuts. .

Situation after change:

- When the main cable damaged, customers are provided from 33kV lines.
- In the event of more than one fault at the same time, the possibility of separating the current from consumers is less.

4.3 Scenario 2

4.3.1 Development of the main network of Halhul area

- Status today

  Halhul area feeds through overhead network from the Duhdah Station at 11 kV. Loads have reached high values over the past years because of the increase in energy consumption. The Halhul network contains 40 distribution transformers and the network lengths are as follows:

  Overhead Network: 15 km

  Underground Cables: 4 km

- After development

  A study was carried out to add a new main station (33/11)kV to be fed from a new main point (10MVA) .The station contains one power transformer , 7 circuit breakers and one Aux. transformer. Loads were distributed to four feeders at 11kV. The station will feed from the Halhul bridge area with a cable of 2 km or from Nuba area, which is far about 7 km as in fig (4.6) and (4.7).

Figure (4.6): The location of a new main station in Halhul

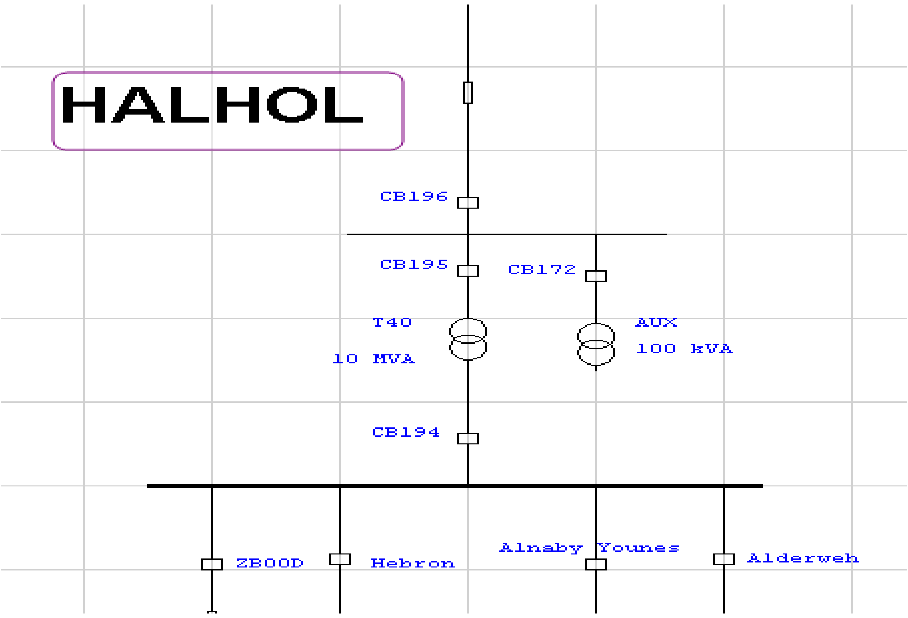


Figure (4.7): The new main station in Halhul

All real loads were entered into the ETAP program and after simulating the load flow as shown in figure :(4.8), As follows:

Losses before adding the new station 212.5 kW

Losses after adding the new station 119.2kW

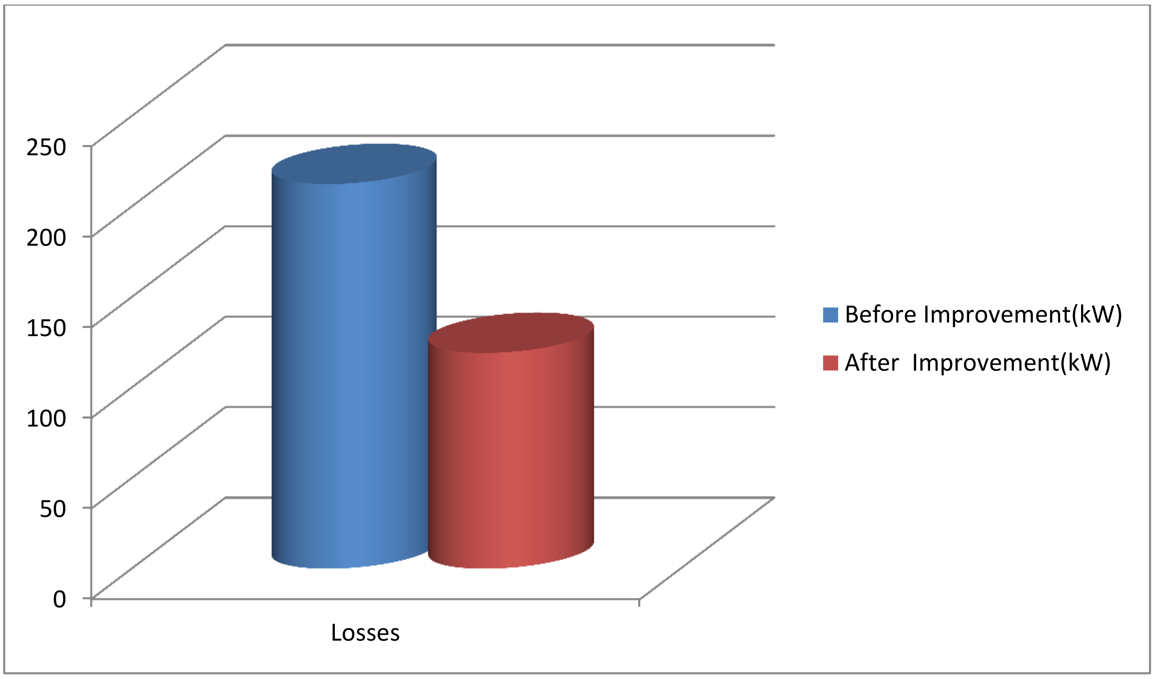


Figure :(4.8) Losses before and after improvement in Halhul.

- The losses were reduced after adding a new station by 93kW as in appendix A
- Value of annual losses 93KW *8760 =814,680 kWh
- Saving in losses after development = kWh * Tariff of kWh

  814,680 *0.47= 382,899 NIS

- The addition of Halhul station led to a reduction in load from Duhdah Station and thus a better distribution of loads especially during peak load times at both stations.
- In addition to above, the addition of Halhul Station leads to increase in reliability, where the load will be divided into four sub-feeders, which will help to reduce the power failure time due to faults.

4.4 Scenario 3

4.4.1 Improve the performance of Al Flahs Station

In order to improve the performance of Al Flahs Station, the cables, transformers and switchgears data were collected as in table (4.3).

Table (4.3) Lengths of Distribution Networks for industrial area

Conductors	Quantity (km)
Underground 33kV Aluminum Cable 300 mm^2	5.1 km
Underground 11kV Cupper Cable 150 mm^2	12.025 km
Overhead Network 11kV	18.192 km
Total	35.5 km

It is important to improve the performance of Al Flahs station for the following reasons:

1. The maximum load can be transfer by the cable is 24MVA while the capacity of the transformers in the substation is 33MVA.
2. The continuous interruptions in an important industrial area in the city of Hebron, where the main cable supplied to the station has been interrupted several times as example from 4.2017 to 8.2017 as shown in table (4.4)

Table (4.4): Number of interruptions

Date	From	To
12.4.2017	4:53 PM	3:22 AM
19.7.2017	10:35 AM	5:45 PM
14.8.2017	2:43 PM	7:55 PM
16.8.2017	4:31 PM	9:05 PM

3. High losses due to cable quality (aluminum).

To improve the performance of the Al Flahs station, the following solutions are required:

1- Add a new main cable from the South or from the MPC station to the Al Flahs station to use the all capacity.
2- Change the design of the station so that new circuit breaker and coupler added to the stations as in Fig (4.9 A and B)

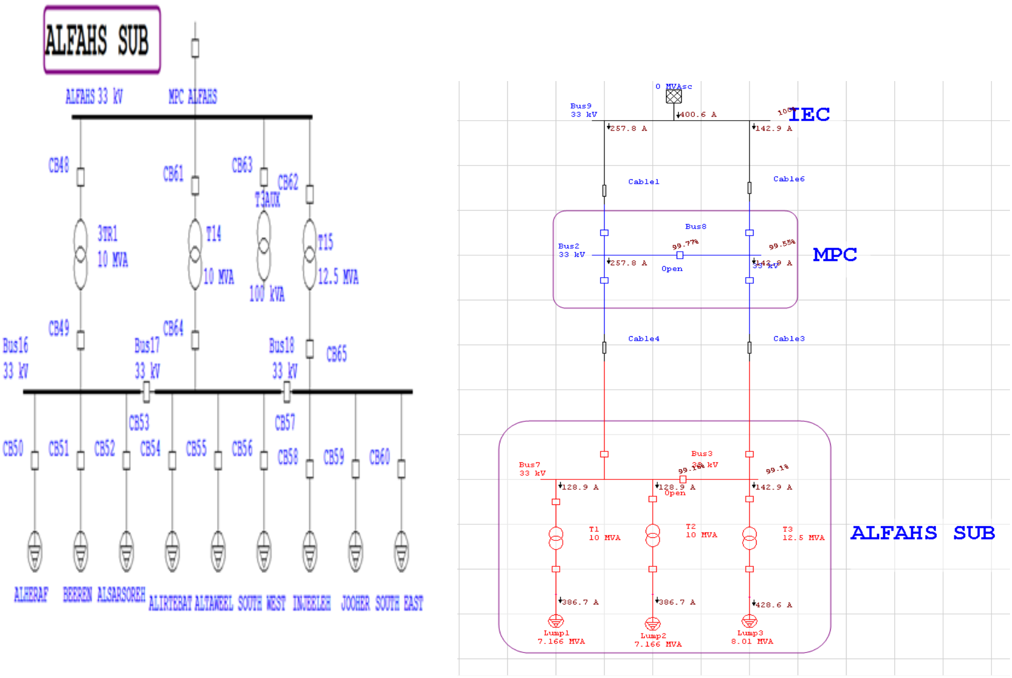


Figure :(4.9) A: Station before change B: Station after change

Reduce losses by note that:

- The length of the main aluminum cable of the station 3.9km as in table 2.2
- The rated current 420 Ampere as in appendix B.
- The cross section of the cable 3*(1*300 Cu) mm^2 as in appendix B.

The New Circuit:

- Reinforcement the main cable for the Alfahs Station by adding new cupper cable from MPC Station.
- Specifications
  - i. The length of the main cupper cable of the station 3.9km
  - ii. The rated current 525 Ampere as in appendix B.
  - iii. The cross section of the cable 3*(1*300)mm

- After analysis on the ETAP, it was found that the losses of the main feeder cable when loading the Al-Fahs station in the industrial zone at peak hours are 406 kW as it shown in the table in appendix B. When adding new cupper cable, the losses will reduce to 227 kW which means saving 522680 kWh per year and saving 245659 Nis annually.

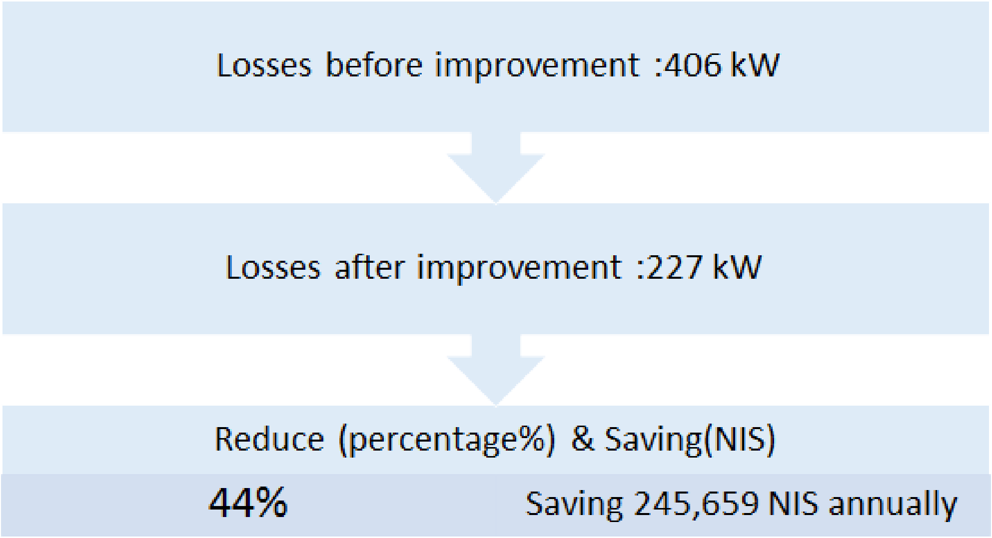


Figure :(4.10) Losses before and after losses improvement to Halhul

3- Improve the power factor at the Al Flahs Station

The data collected from the Hebron distribution network, showed a decrease in the power factor at Al Flahs substation as in Figure (4.11),. In the night hours when factories stop working, the power factor leads to the use of static capacitors on the network, knowing that the power factor at peak hours reaches to 0.82 lagging. According to that we need to study and develop the best possible technical and economic solutions to improve the power factor to be more than 0.92

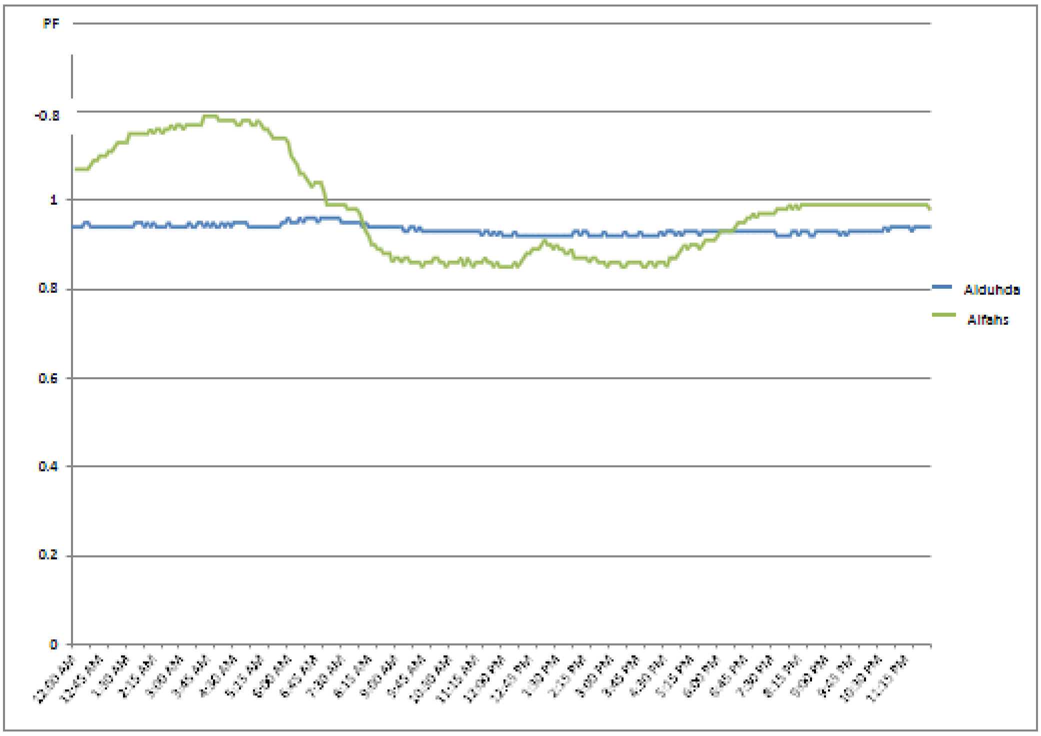


Figure (4.11): The Difference between the power factor in the Alduhda and Alfahs Substations.

4.4.2 Power Factor correction

A typical utility system would have a reactive load at 80% power factor during the summer months. Therefore, in typical distribution loads, the current lags the voltage. The cosine of the angle between current and sending voltage is known as the power factor of the circuit. If the in-phase and out-of-phase components of the current I are multiplied by the receiving-end voltage VR, the resultant relationship can be shown on a triangle known as the power triangle. The triangular relationship that exists between kW, kVA, and kVAR. Note that, by adding the capacitors, the reactive power component Q of the apparent power S of the load can be reduced or totally suppressed. Figures (4.12) and (4.14) illustrate how the reactive power component Q increases with each 10% change of power factor. Figure (4.12) also illustrates how a portion of lagging reactive power Q old is cancelled by the leading reactive power of capacitor Qc. Even an 80% power factor of the reactive power (kVAR) size is quite large, causing a 25% increase in the total apparent power (kVA) of the line. At this power factor, 75 kVAR of capacitors is needed to cancel out the 75 kVAR of the lagging component. The generation of reactive power at a power plant and its supply to a load located at a far distance is not economically feasible, but it can easily be provided by capacitors (or overexcited synchronous motors) located at the load centers. Figure (4.15) illustrates the power factor correction for a given system. As illustrated in the figure, capacitors draw leading reactive

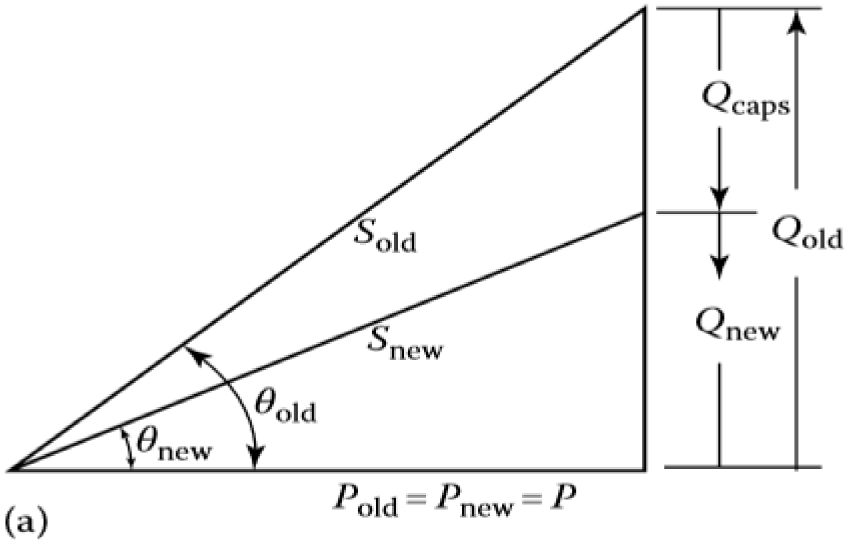


Figure (4.12): the use of a power triangle for power factor correction by employing capacitive reactive power.

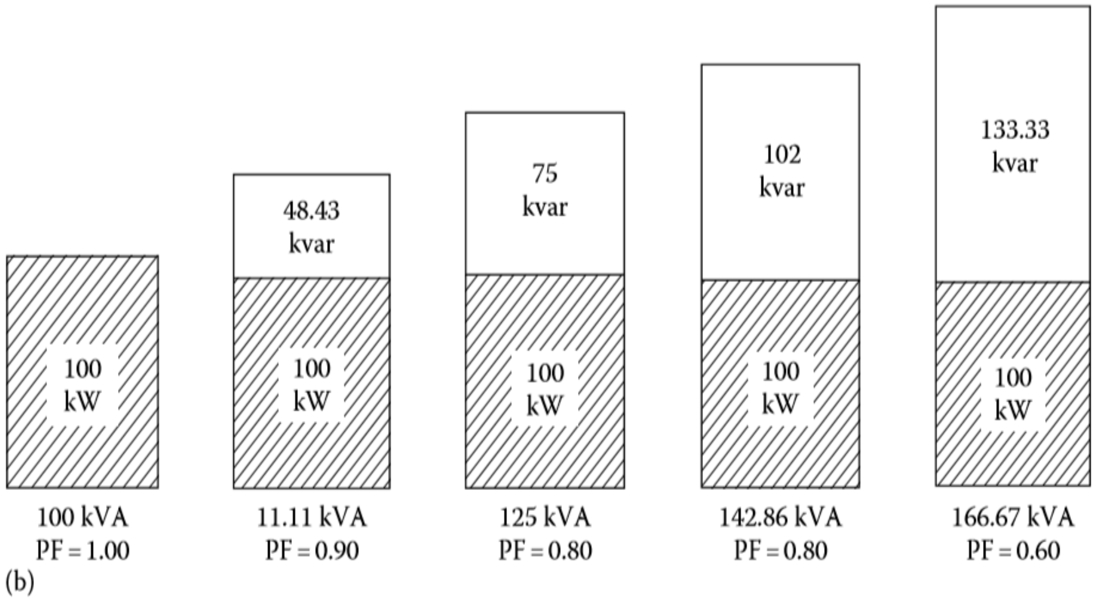


Figure (4.13): The required increase in the apparent and reactive powers as a function of the load power factor, holding the real power of the load constant.

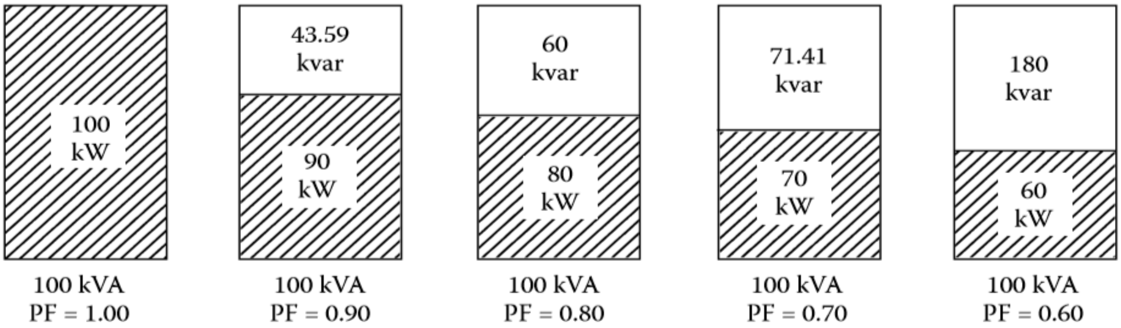


Figure (4.14): The active powers as a function of the load power factor, holding the apparent power of the load constant

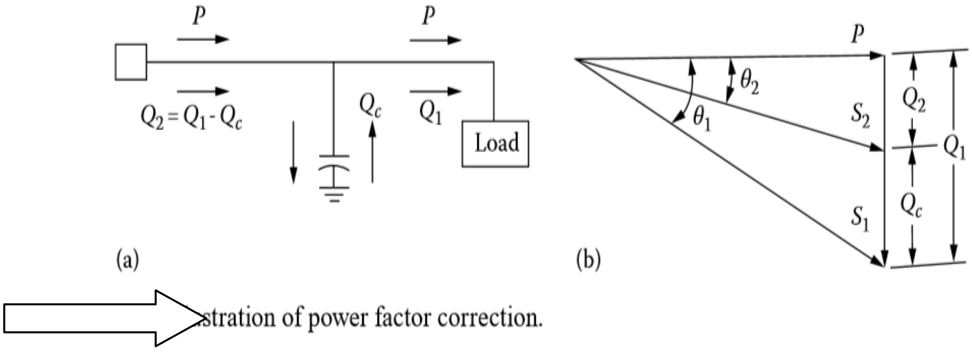


Figure (4.15a,b) Illustration of power factor correction

4.4.3 Optimal location of capacitor bank

Commonly, the shunt capacitors are used to supply a capacitive type-Leading VAR reactive power to the AC Power system at the point of connection for several advantages such are ; (a) To reduce the lagging component of the circuit current (b) To increase the voltage of the load bus (c) To improve bus-voltage regulation and /or power factor (d) To reduce transmission losses and (e) To reduce Electricity Billing cost based on kVA Demand . In addition to that, capacitors are widely used in distribution systems to reduce energy and peak demand losses, release the kVA capacities of distribution apparatus and to maintain a voltage profile within permissible limits. The power capacitor can be considered to be a VAR-GEN (reactive power Source), since it actually supplies needed-magnetizing current requirements for inductive loads. The fundamental function of power capacitor is to provide needed reactive power compensation. Furthermore, the objective of optimal capacitor placement problem is to determine the size, type, and location of capacitor banks to be installed on radial distribution feeders to achieve positive economic response. The economic benefits obtained from the loss reduction weighted against capacitors costs while keeping the operational and power quality constraints within required limits. The capacitor location or placement for low voltage systems determines capacitor type, size, location and control schemes. The optimal capacitor placement is generally a hard combinatorial optimization problem that can be formulated as a nonlinear/search minimization problem[6]. Almost all the methods to solve capacitor placement problems are based on the historical data of the load models and associated cost of the energy and the cost of capacitor banks. The cost $/kVAR for power savings and losses (power losses/energy losses). However, historical data and load models are uncertain and may change in reality. In general, capacitor placement problems can be solved in two steps. The first step is the use of load flow model and find the V, P,Q at all the buses and also the feeder losses . The second step is to minimize the cost function-Jo-min - subject to constraints, like practical limits of voltage and capacitor size.

Many of the previous strategies for capacitor allocation in the literature are also limited for the application to planning, expansion or operation of distribution systems. Very few of these capacitor allocation techniques have the flexibility of being applicable to more than one of the above problems. Figure(4.16) shows the block diagram of the best location of capacitor proposed for losses minimization.

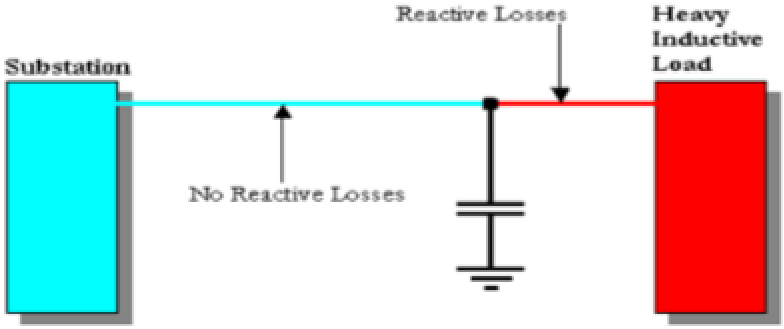


Figure (4.16) optimal location of capacitor bank

When capacitors of appropriate size are added to the grid at appropriate locations, the power losses can then be minimized by reducing the reactive power component in, thereby reducing the observed power demand[8]. Indeed, there are many aspects to this compensation and its effects, depending on where capacitors get to be located, what are the optimal sizes, and the details of the distribution circuit. Obviously properly switched capacitors located at appropriate locations along distribution feeders provide great financial benefits to the utility. In addition, if there is to be only one capacitor bank on a uniformly loaded feeder, the usual two thirds, two-thirds rule gives optimum loss and demand reduction[9]. This means that the bank kVAR size should be two-thirds of the heavy load kVAR as measured at the substation, and the bank should be located two-thirds the length of the feeder from the substation. If the objective is voltage control the bank should be farther from the substation. With several banks on a uniformly loaded feeder, the total capacitor kVAR can more closely match the total load kVAR. Depending on the type of the switching control used, multiple banks on a feeder can lead to ‘pumping’ as the controls affect the operating points of each other[10]. Usually no more than three or four banks are used per feeder. In fact, in the case of concentrated industrial loads, there should be a bank, sized to almost equal the reactive load current, located as close to each load as possible.

To improve the power factor, a Capacitor bank unit must be installed so that each consumer consumes an industrial load will reduce the current and therefore the losses passing through cables, transformers and main distribution lines will reduced.

4.4.4 Case Study for customers in the industrial area

Table (4.5) Table of low power factor - Classification of the Palestinian Energy Authority

PF in consumer	Additional cost on monthly BILL
0.92 and above	nothing
0.92 - 0.70	0.77% of the monthly bill value per 0.01 factor of the power factor less than 0.92
70 - 0.60	0.95% of the monthly bill value per 0.01 factor of the power factor less than 0.92
0.60 - 0.50	1.20% of the monthly bill value per 0.01 factor of the power factor less than 0.92
Below 0.50	1.50% of the monthly bill value per 0.01 factor of the power factor less than 0.92

The data of all costumers in the industrial zone were collected and the low power factor in the region was shown as in appendix C.

After a study of economic feasibility as in table (4.5) and (4.6) the cost of capacitor bank is 625,000 NIS, the cost of installation and maintenance is 250,000 NIS. The total fines 212,534 NIS and the average for customers to return the cost value 4 months.

Table (4.6) Classification for average Power Factor for Consumers in the Industrial Area

Average PF for consumer	Number	Per. (%)	COSΘ1	kWh	kVAR Q1	kVAR Q2	COSΘ2	Q1-Q2
Below 0.50	2	2	0.48	27.00	49.35	10.67	0.93	38.68
0.60 - 0.50	6	4	0.56	73.92	109.83	29.21	0.93	80.61
0.70 - 0.60	40	29	0.64	85.46	100.75	33.78	0.93	66.97
0.92 - 0.70	56	41	0.78	106.75	83.28	42.19	0.93	41.09
above 0.92	29	24	0.95	82.36	25.39	0.00	0	

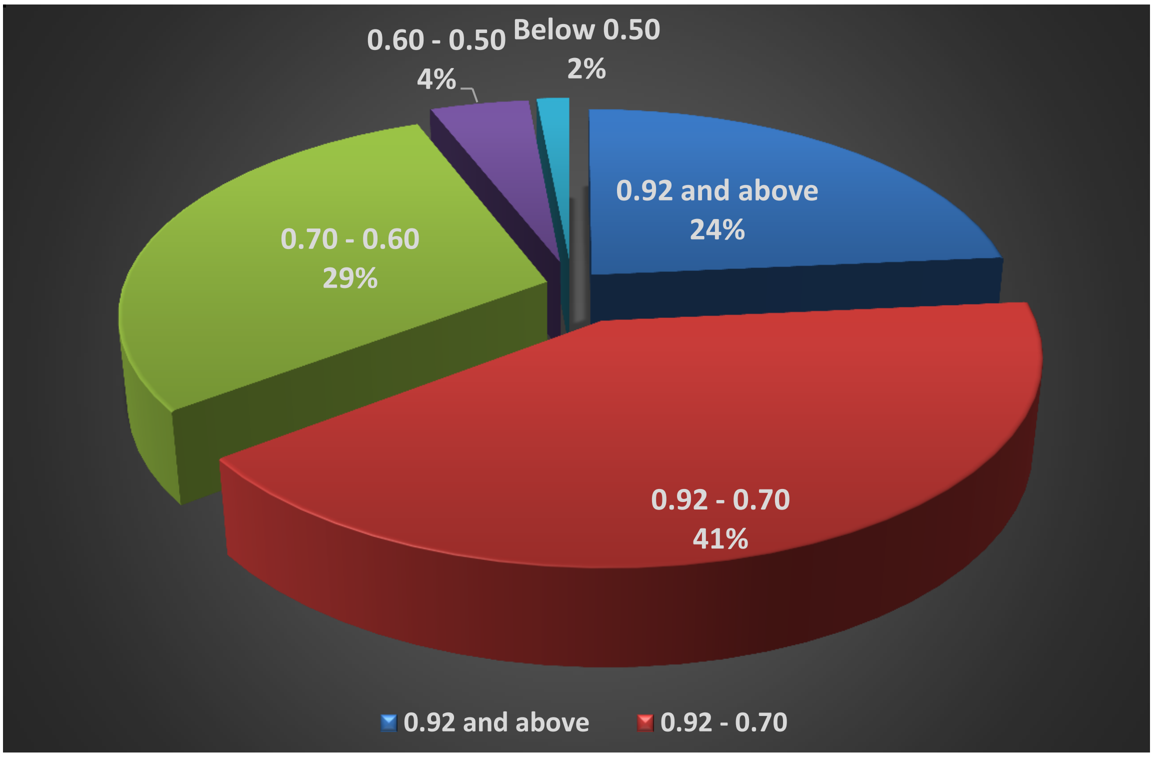


Figure (4.17) Classification of Power Factor for Consumers in the Industrial Area.

Case Study for one of customers in the industrial area

Real power (P) = 6I280 kWh in month

Reactive power (Q) =55699 kVAR in month

$$\text{Energy per hour} \ = \frac{\text{Energy in month}}{\text{num of day} * \text{num of hour}}$$

(4.1)

$$\text{E} = \frac{6\text{I}280 \text{ kWh}}{26 * 8} = 294.615 \text{ kWh}$$

$$\text{Q (Hour)} = \frac{55699 \text{ kVar}}{26 * 8} = 267.783 \text{ kVARh}$$

Apparent power(S) $= \sqrt{\text{P}^2 + \text{Q}^2}$= 398.1277 kVA (4.2)

Power factor (PF) $= \frac{\text{p}}{\text{S}} = \ 0.74$ (4.3)

When improve PF to 0.93

θ =$\cos^{-1}$ 0.93 =21.56 deg

Qnew=P$*$ tan 21.56=116.44kVAR (4.4)

Qc = Q-Qnew=267.783-116.44=151.343kVAR (4.5)

We need Control capacitor bank = 200 kVAR

The cost of the Control capacitor bank (200kVAR) 12000 NIS

0.92 – 0.74 = 0.18

0.18 * 0.77 = 0.1386 as in table (4.2)

The cost (Bill) = P * Tariff of kWh = 294.615 kWh * 0.57 = 34930 NIS

The value of the fine = 34930 * 0.1386 = 4841.3NIS

Payoff is about = 12000 / 4841.3 = 2.5 month

Bill = 34930 + 4841.3 = 39771.3 NIS

The customer can return the cost value during 2.5 months.

$$\mathrm{I} = \frac{\mathrm{S}^*}{\mathrm{V}^*} = \frac{398.1277\ \mathrm{kVA}}{400 * \sqrt{3}} = 574.647\ \mathrm{A\ and}\ \Theta = -37\mathrm{deg} \tag{4.6}$$

$$\mathrm{Snew} = \sqrt{\mathrm{P}^2 + \mathrm{Qnew}^2} = \sqrt{294.615^2 + 116.44^2}$$

$$= 316.8\mathrm{kVA}$$

$$\mathrm{Inew} = \frac{\mathrm{S}^*}{\mathrm{V}^*} = \frac{316.8\mathrm{kVa}}{\sqrt{3} * 400} = 457.26\ \mathrm{A}$$

The current decrease 117.387A

$$\%\ \text{losses reduction} = 100 - 100\ \left(\frac{\text{PF orginal}}{\text{PF corrected}}\right)^2 \tag{4.7}$$

$$= 100 - 100\ \left(\frac{0.74}{0.93}\right)^2 = 36.68\ \%$$

The power losses of an electric conductor depend on the resistance of the conductor itself and on the square of the current flowing through it. Since, with the same value of transmitted active power, the higher the power factor, the lower the current, it follows that when the power factor rises, the losses in the conductor on the supply side of the point of application of power factor correction equipment will decrease.

In a three phase system the losses are expressed as follows:

$$P_{LOSSES} = 3 \times R \times I^2 \tag{4.8}$$

Therefore, improvement in power factor results in a corresponding decrease in current which results in a reduction in power losses by the square of the current reduction.

Electric utilities can often justify power factor correction on the basis of loss reduction due to the resistance and magnitude of power flow associated with long transmission and distribution lines. For industrial customers, justification of power factor correction on the basis of loss reduction is difficult as losses are comparably lower.

Power factor correction on industrial power systems is most often cost justified (or mandated) based on power factor penalties and/or kVA charges, released system capacity, or the production benefits associated with improvements in power quality with the application of power factor correction equipment and harmonic filters.

In addition to losses associated with I2R losses from current flow through series resistance of power conductors, and transformer windings, a portion of power system losses come from hysteresis and eddy currents in the iron laminations of motors, generators, and transformers. These losses are not reduced by power factor correction and are largely dependent on system voltage rather than system current.

A study has been conducted through the ETAP program so that the power factor is improved to 0.93as in appendix B. Losses decreased by 16.6% as shown in fig (4.18) and (4.19)

The improvement of the power factor is a common interest to electric company and customer as in the table

These solutions will reduce interruptions and increase reliability on the Al Flahs station network as in figure (4.19) and table (4.7).

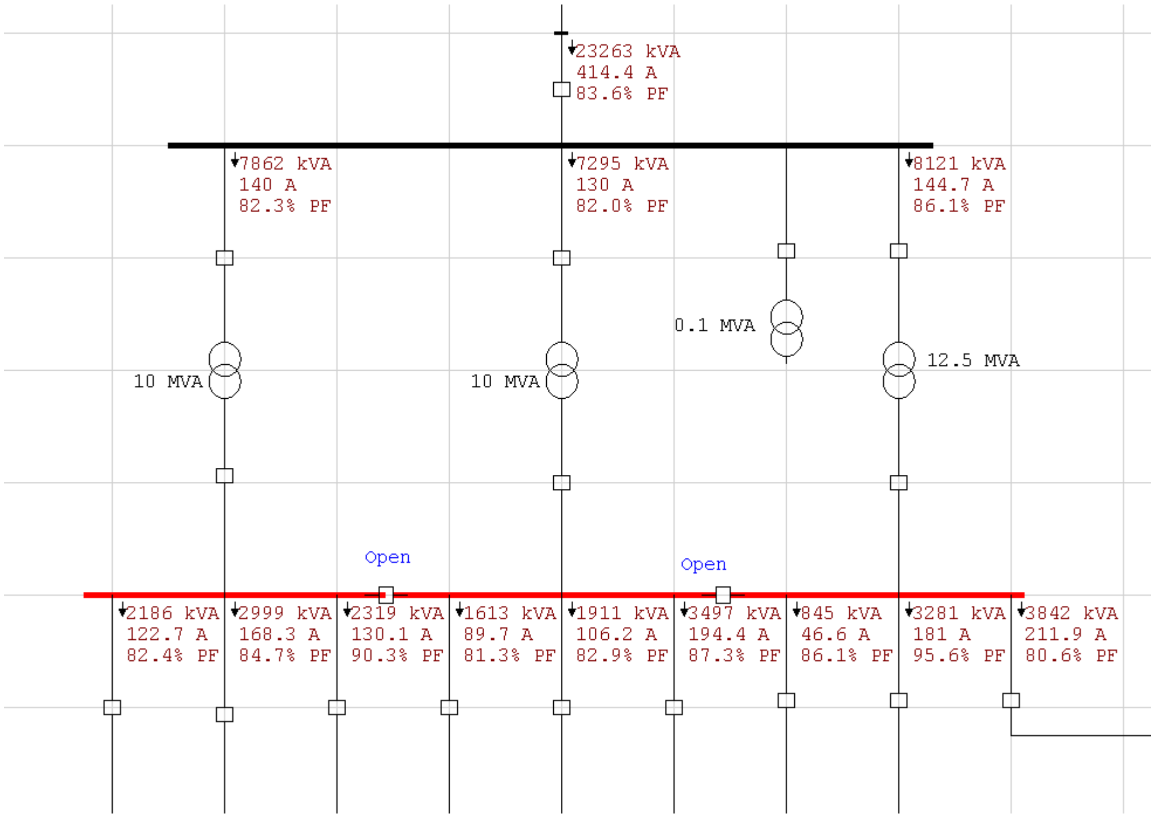


Figure (4.18) Power factor in Al Fahs Station before improvement

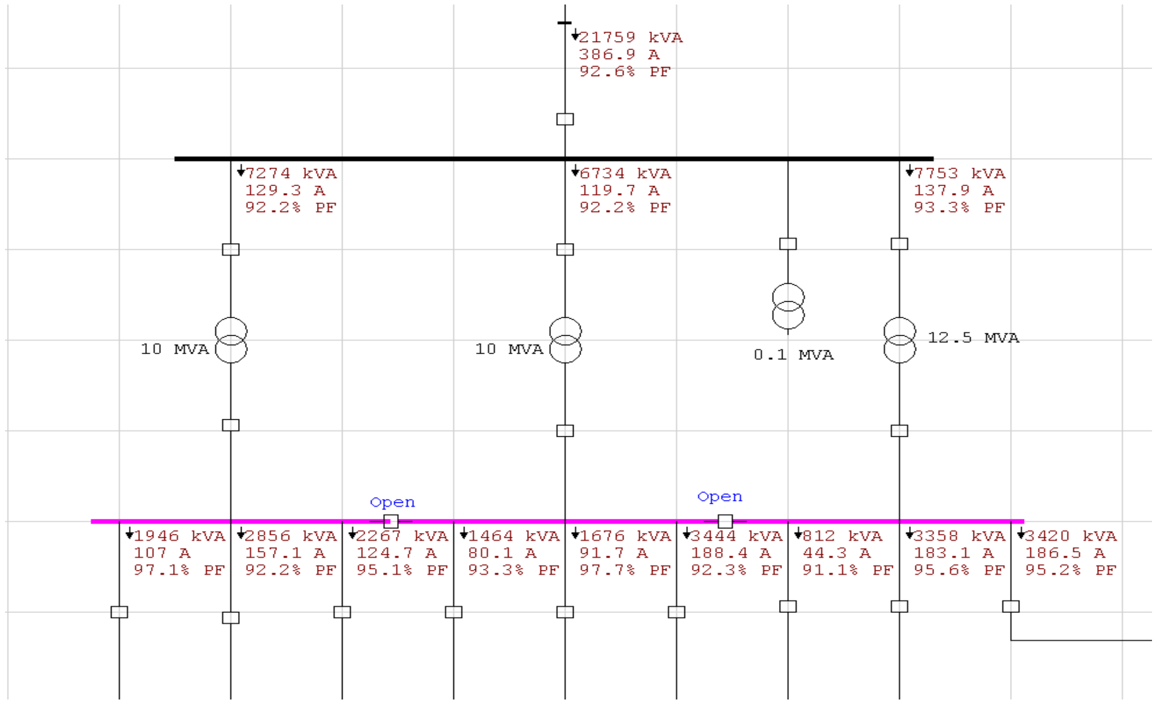


Figure (4.19) Power factor in Al Fahs Station after improvement

Table (4.7) Improvement for Al Fahs Station

	Before Improvement	After Improvement	Difference
Power Factor (%)	**83.6**	**92.6**	**9**
Total Losses (kW)	**821.9**	**685.3**	**136.6**
Apparent Power (MVA)	**23.26**	**21.75**	**1.51**
Current (A) at 33kV	**414.4**	**386.9**	**27.5**

4.5 Scenario No.4

4.5.1 Technical losses in Hebron Network

The following table shows the quantity of purchases and sales from 2012 to 2016. Technical and non-technical losses range from 19% to 20%, and total losses for 2016 amounted to 31,261,372 NIS as in table (4.8).

If losses are reduced by 1%, this means saving 1,645,335 NIS

Table (4.8) Sales and Purchases

Statement	2012	2013	2014	2015	2016
Sales kWh	300,033,050	298,902,242	305,512,904	327,546,410	342,052,257
Sales NIS	189,091,159	202,491,542	212,005,335	213,261,791	211,084,321
Purchases(kWh)	369,219,480	373,086,120	379,030,800	411,243,600	421,484,910
Purchases(NIS)	177,293,501	193,626,932	207,562,455	192,840,853	179,822,949
Losses%	19%	19.8%	19%	20%	19%
Debts until the end of the year	390,297,405	439,270,223	445,834,925	451,021,796	484,175,332
Losses(NIS)%	11,797,658	8,864,610	4,442,880	20,420,938	31,261,372

4.5.2 Losses in Distribution systems

Power generated in power stations pass through large and complex networks like transformers, overhead lines, cables and other equipment and reaches at the end users. It is fact that the unit of electric energy generated by Power Station does not match with the units distributed to the consumers. Some percentage of the units is lost in the distribution network.

This difference in the generated and distributed units is known as Transmission and Distribution loss. Transmission and Distribution loss are the amounts that are not paid for by users.

T&D Losses = (Energy Input to feeder (kWh) – Billed Energy to Consumer (kWh)) / Energy Input kWh x 100 (4.9)

There are two types of Transmission and Distribution Losses:

1. Technical Losses
2. Non-Technical Losses

Technical Losses

The technical losses are due to energy dissipated in the conductors, equipment used for transmission line, transformer, sub transmission line and distribution line and magnetic losses in transformers.

The major amount of losses in a power system is in primary and secondary distribution lines. While transmission and sub-transmission lines account for only about 30% of the total losses. Therefore the primary and secondary distribution systems must be properly planned to ensure within limits.

- The unexpected load increase was reflected in the increase of technical losses above the normal level
- Losses are inherent to the distribution of electricity and cannot be eliminated.

4.5.3 Losses reduction advantages

- Technical advantages cover a wide variety of issues such as peak load saving, good voltage profile, reduced system losses, improved continuity and reliability, removal of some power quality problems.

- Besides the financial implications, low-loss design improves reliability, lessens power quality concerns, and better accommodates customer load growth.

- There’s an environmental twist to lowering distribution losses: Lowering distribution losses reduces the amount of pollutants and greenhouse gasses from hydro-carbon based power plants.

- Utilities can reduce distribution losses by concentrating on the design and operation of the distribution system.

- Some of loss-reduction measures require financial commitment, forcing energy-conscious utilities to balance loss savings with capital investment.
- Reducing the total system losses could be of interest to some utilities in the developing countries as some of them are losing 15-20% of their total generation as losses while this figure for a well-developed power system is well under 10%. However, the placement and size of the DG are two crucial factors in loss reduction.
- System Losses in the Grid Transmission and distributions losses constitute a major portion of system losses. This is an old and well-researched area. However, there is a great potential for loss reduction in some of the developing countries in Asia, System losses, in practice, mean two types; one is the capacity or kW loss and the other one is energy or kWh loss, which can result in a larger monetary value at the end of each year. Even though the losses cannot be completely removed, they can be brought down to an acceptable value.

4.5.4 Drawbacks of network losses

High rate of technical and non-technical losses might cause:

1. Poor quality of service offered to customers.
2. High cost due to useless or premature investments.
3. Reduction in revenue resulting in cash difficulties with all ensuing economic consequences

    - Technical losses are part of the electric losses in the system, resulting from: losses in drivers, corona effect, eddy currents, and ohmic losses.
    - These losses can still be grouped according to the segment of the electric system where it happens, being subdivided into:

    1. Losses in the transmission system.
    2. Substation power transformers.
    3. Primary distribution system.
    4. Secondary distribution system.

5. Connection extensions.
6. Measurement systems.

4.5.5 Transformer losses

Classified into two components, namely, no-load and load losses:

- No-load losses: occur from the energy required to retain the continuously varying magnetic flux in the core and its invariant with load on the transformer.
- Load loss: mainly arises from resistance losses in the conducting material of the windings and it vary with loading.
- The cost of losses is the most important factor in selecting a transformer because it is quite possible for the estimated value of future losses to exceed the first cost of a transformer. Therefore, the right balance between the initial expenses and the upcoming loss expenses should be considered when buying a transformer.
- **Technical losses can be reduced by taking the following actions:**

1. Install capacitor banks.
2. Re-conducting overloaded lines with bigger conductors.
3. Avoid any overloading of system and monitor the progress in losses reduction.
4. Disconnect unloaded transformers to avoid no-load losses.
5. Balance the transformer loading to reduce the neutral current and power losses.
6. Upgrade transformers to match the load and the installed capacity, and to replace old/degraded ones.
7. Ensure that all industrial customers are meeting the requirement of 0.9 PF.
8. Perform regular preventive maintenance.

Ensure the frequent live-line washing to reduce the leakage current.

4.5.6 Losses in power overhead lines and cables:

One of the main sources of losses in the distribution system is the copper losses in power overhead lines and cables. Since these losses are a function of current flow through the line.

So, saving just 1 % on the electrical energy produced by a power plant of 1 000 megawatts means transmitting 10 MW more to consumers, which is far from negligible: with the same energy we can supply 1 000 - 2 000 more homes.

- The length of cables between a power plant and a step-up substation is short since they are usually installed in the same place, so the energy losses there are quite low. The situation is not the same between the step down substation and users where kilometers of medium and low voltage cables must be erected or buried to reach them. In order to reduce the cost and power losses in the power converter, different configurations of 1ph-to-3ph converter with a reduced number of power devices

4.5.7 Non-technical losses:

- Non-technical losses include:

1. defective/incorrect metering,
2. Human error on installation.
3. Administrative processes.
4. Non metered authorized customers, especially, theft.

- In several cases, when total power losses of the system are large, it becomes evident that part of non-technical losses (net company revenue loss) is serious because theoretically the technical losses typically vary between 3 % and 6 %.
- This depends on the length of line, age of the system, voltage level and other factors. The estimated energy theft in some of the third-world countries is staggeringly high in the range of 10 % to 40 %, contrary to the developed countries where it reaches up to 3 %.

- It has been found that non-technical losses can easily be reduced or even eliminated by applying the following actions:

1. Perform regular inspection to randomly select and any suspected customers.
2. Install new meters at the primary substation to measure the internal consumption and invoice the company to avoid considering substation consumption as losses.
3. Survey and identify the defective meters to replace them.
4. Replace meter seals with new tamper-proof ones.
5. Conduct regular campaign to increase the customers' awareness with the efficient use of electricity.

Hebron power stations contain 15 power transformers and in total capacity 162 MVA and the number of distribution transformers 619 and in total capacity 281855 kVA and by collecting transformers data from the nameplate the no load losses in power transformers is 132528 kW and in distribution transformers is 424,496 which means that the operational cost of all transformers 2,342,174,515 NIS.

Table (4.9) No Load Losses in Distribution Transformers

Number	kVA	Number of Transformer	(kVA*num)	No load losses (kW)
1	1000	32	32,000	37,579
2	800	42	33,600	44,108
3	630	148	93,240	93,106
4	500	18	9,000	15,300
5	400	180	72,000	134,222
6	315	9	2,835	5,850
7	250	108	27,000	58,747
8	200	2	400	900
9	160	63	10,080	28,224
10	100	17	1,700	6,460
Total	4355	619	281,855	424,496

The utilization factor:

The utilization factor gives an indication of how well the capacity of an electrical device is being utilized.

$$\text{utilization factor} \quad = \frac{\text{Maximum kVA demand}}{\text{Transformer kVA rating}} \qquad (4.10)$$

$$\text{utilization factor for Distribution transformers UF} = \frac{110\ \text{MVA}}{280\ \text{MVA}} = 0.392$$

Which shows that the utilization factor in Distribution transformers is low. Economically, the utilization factor should be close to one as a criterion for losses So that the capacities of the transformers and consumptions are suitable.

Which means:

1-The capacities of distribution transformers are greater than twice the maximum load.

2- Total losses at no load are high.

No Load Losses in Power transformers:

Table (4.10) No Load Losses in Power transformers

number	MVA	Numbers of transformer	MVA*Num	Noload losses (kw)	Total noload losses(kw)
1	10	10	100	8751	87510
2	13	2	26	9260	18520
3	13	2	26	9111	18222
4	10	1	10	8765	8765
		Total	162		133017

And where the total losses amounted to 31,261,372 NIS there for the losses in transformers at no load are equal to 7.49% of the total losses.

utilization factor for power transformers UF $=\frac{110\ \text{MVA}}{162\ \text{MVA}} = 0.679$

Which shows that the utilization factor in power transformers is suitable as in table (4.10).

Load factor

Definition: Load factor is defined as the ratio of the average load over a given period to the maximum demand (peak load) occurring in that period. In other words, the load factor is the ratio of energy consumed in a given period of the times of hours to the peak load which has occurred during that particular period.

$$Average\ demand = \frac{Total\ energy}{Hours} = \frac{424645MWh}{8760} = 48.4754\ Mwh \tag{4.11}$$

$$Load\ Factor = \frac{Average\ demand}{Maximum\ Demand} \tag{4.12}$$

$$= \frac{48.4754\ \text{MWh}}{104\ \text{MWh}} = 0.466$$

The optimal load factor is 1.00

4.5.8 Losses in distribution transformers

It has been shown that many distribution transformers do not fit their capacities with loads as shown in Appendix F

4.6 Scenario 5

4.6.1 Case study of the 33kV Hebron network

Using the ETAP power program, the real values of the network components and the required values were entered and the maximum load time of 2016 was selected. The results showed a loss of 1378.6 kW, which means 1% of the total load as shown in Figure (4.20) and in appendix E.

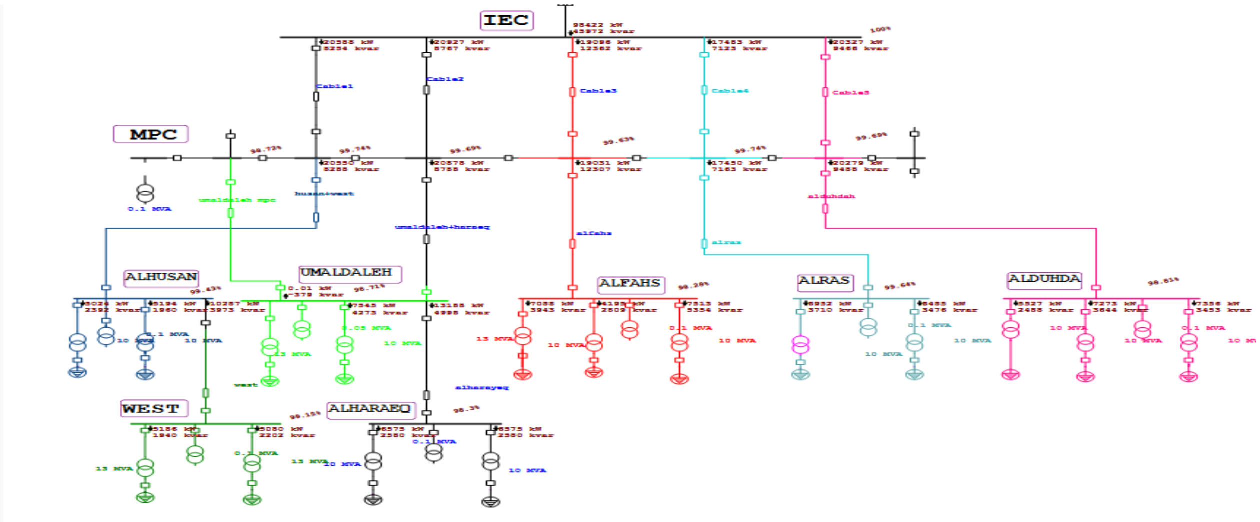


Figure (4.20): Single line Diagram for Hebron 33kV Network from ETAP

In addition, the network was analyzed at different times as in the following table (4.6).

Table (4.11): Network analysis at different times

Type	Date	Load(MVA)	Losses(kW)
Average load	**11.5.2017**	**74.4**	**701.8**
summer	**3.7.2017**	**87.1**	**888**
Winter(Peak)	**31.12.2016**	**104**	**13778.6**

4.6.2 Effect of adding new Main Points

The effect of operating new link points on a network was simulated so that loads were distributed to all main stations (15MVA to every station) and the losses were reduced to 1066kW as in appendix E which means reducing losses by 22.6% as in figure (4.19).

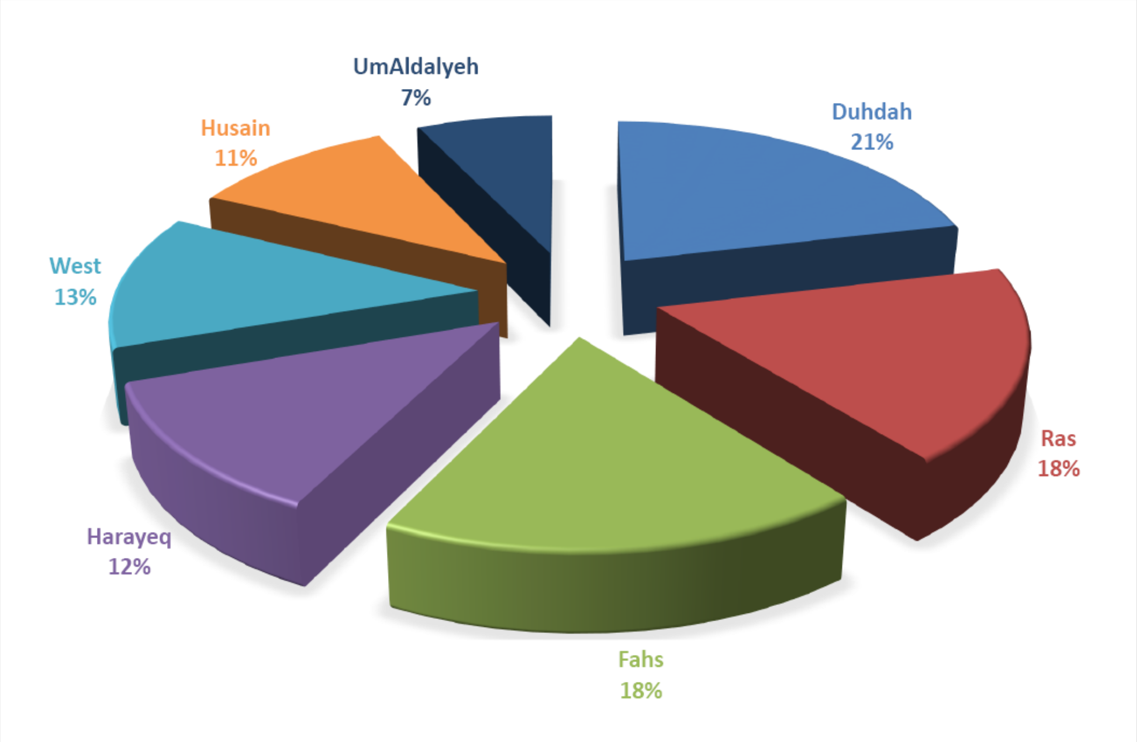


Figure (4.21) Percentage of Power consumption for each Station 2016

Recommendations

1- For Hebron Electricity

- There is a need for development studies using network analysis programs.
- Connect smart meters to all distribution transformers in order to monitor and manage loads.
- Workshop on the utility of improving the power factor of the consumer.
- The importance and necessity of connecting the ring system for 33KV network.
- Use GIS to collect and archive network contents.

2- For our University

- The need for power network simulation programs with all license
- Add new courses for teaching the student how to use Etap and other simulations software’s.

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Abstract

The improvement of the distribution network performance in the electrical systems leads to increased reliability in the service; it also leads to high financial return that encourages investment in this field. Studies show that 30% to 40% of the investment in the electricity sector is spent on distribution system.

In this study, data and statistics were collected from the Hebron distribution network. We entered all the network data to the ETAP software. We analyze the network during peak periods, average loads, and summer time in order to obtain indicators of the network losses and economic feasibility to reduce them. While analyzing the data, we discovered a decrease in the power factor in the Fahus station because of the industrial load in the area. That led us to do economic feasibility to improve the power factor.

Several scenarios have been developed to improve the network performance and efficiency, one recommendation is to build a ring system for the 33 kV network. We analyzed the network when adding new main connections points to the stations of Al-Hussein and Um Al-Daliya. Also we analyzed Halhul network when connected to a main station via a new main point and its impact on the network in general.

In addition, several solutions were developed to solve the problems of the industrial zone by adding main additional feeder to Alfahs Station and studying the effect of improving the power factor on the network.

الخلاصة

ان تحسين أداء شبكة التوزيع في الأنظمة الكهربائية يساعد على زيادة الموثوقية في الخدمة؛ كما انه يحقق عائدا ماليا يشجع على الاستثمار في هذا المجال، وتظهر الدراسات أن 30٪ إلى 40٪ من الاستثمار في قطاع الكهرباء ينفق على نظام التوزيع.

في هذه الدراسة، تم جمع البيانات والإحصاءات عن شبكة توزيع كهرباء الخليل، و ادخال المكونات الرئيسية لكامل الشبكة لبرنامج الإيتاب وتحليل الشبكة خلال فترةالذروة و عند متوسط الاحمال و في أحد أيام الصيف من أجل الحصول على مؤشرات للخسائر الفنية والجدوى الاقتصادية للحد منها، و عند تحليل بيانات المحطات الرئيسية تبين وجود انخفاض في قيمة معامل القدرة في محطة الفحص بسبب الحمل الصناعي في المنطقة مما استلزم عمل جدوى اقتصادية لتحسين معامل القدرة .

لقد تم تطوير عدة سيناريوهات لتحسين أداء الشبكة و رفع كفائتها منها توصية بعمل ربط حلقي لشبكة 33 كيلوفولت ، وقد تم تحليل الشبكة عند إضافة نقاط ربط رئيسية جديدة لمحطتي الحسين وأم الدالية كما تم تحليل شبكة حلحول عند ربطها مع محطة تحويل رئيسية عبر نقطة ربط جديدة و تأثير ذلك على الشبكة بشكل عام.

و بالاضافة لذلك فقد تم وضع عدة حلول لمعالجة مشاكل المنطقة الصناعية عبر اضافة مغذي اضافي لمحطة الفحص و دراسة تاثير تحسين معامل القدرة على الشبكة .

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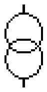
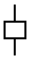
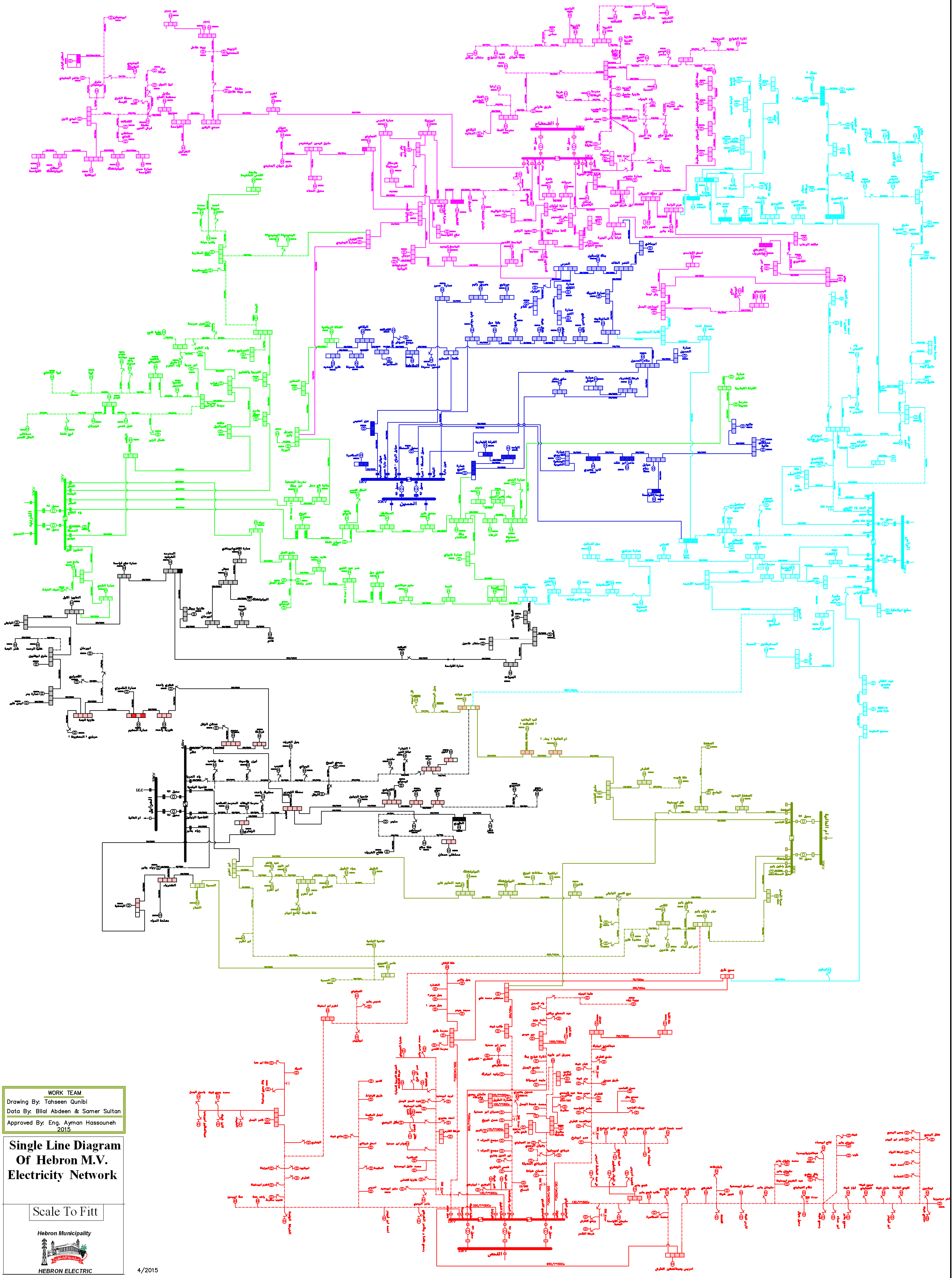
	Abbreviation statement
IEC	Israel Electric Company
MPC	Main power station
S/S	Sub-Station
LV	low voltage
ONAF	Oil Natural Air Forced
ONAN	Oil Natural Air Natural
RMU	Ring Main Unit
CCT(RMU)	Cable,cable,Transformer
ACSR	Aluminum Conductor Steel Reinforced
kWh	Kilowatt-hour
LOSSES	The power system losses
AUX Transf.	Auxiliary Transformer
ETAP	Electrical Transient Analysis Program
MW	Mega Watt
NIS	New Israeli Shekel
MVA	Mega Volt Ampere
kV	Kilovolt
SCADA	Supervisory Control and Data Acquisition

List of Symbols

	Bus
	Transformer
	Circuit Breaker
	Cable
	Load



WORK TEAM
Drawing By: Tahseen Qunibi
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2015

Single Line Diagram Of Hebron M.V. Electricity Network

Scale To Fitt

Hebron Municipality

HEBRON ELECTRIC

4/2015