LOSSES IN ELECTRIC DISTRIBUTION SYSTEMS

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DECEMBER 2006

LOSSES IN ELECTRIC DISTRIBUTION SYSTEMS

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

KEREM ÖZEL

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
ELECTRICAL AND ELECTRONICS ENGINEERING

DECEMBER 2006

Approval of the Graduate School of Natural and Applied Sciences

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ABSTRACT

LOSSES IN ELECTRIC DISTRIBUTION SYSTEMS

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December 2006, 118 pages

The purpose of this thesis is to examine the technical losses in Electric Distribution Systems, the sources of the losses, minimum levels of the losses, ways to decrease the losses and current applications in Turkey. The wrong and weak parts of the current applications are determined and emphasized. Ways to decrease losses in Distribution Systems are advised.

The energy resources in the world are decreasing rapidly. There is a rapid growth in consumption. It is a must to use existing resources in most efficient way because there is no unlimited energy source. Losses in the electric distribution systems are one of the most important subjects because the most of the technical losses in electric systems occur in the distribution systems.

Keywords: Electric Losses, Electric Distribution System

ÖZ

ELEKTRİK DAĞITIM SİSTEMLERİNDE KAYIPLAR

Özel, Kerem
Y.L., Elektrik ve Elektronik Mühendisliği Bölümü
Danışmanr: Prof. Dr. Nevzat Özay

Aralık 2006, 118 sayfa

Bu tezin amacı Elektrik Dağıtım Sistemlerinde oluşan teknik kayıpları, bu kayıpların kaynaklarını, kayıpların en alt sınırlarını, kayıpları azaltma yollarını, Türkiye'deki mevcut uygulamaları incelemektir. Mevcut uygulamaların doğru ve eksik yanları tespit edilerek vurgulanacaktır. Dağıtım sistemlerindeki kayıpların azaltılmasına yönelik önerilerde bulunulacaktır.

Dünyadaki enerji kaynakları hızla azalmaktadır. Talep ise hızla artmaktadır. Sınırsız olan bir enerji kaynağı bulunamamış olması sebebiyle, mevcut kaynakların en verimli şekilde kullanılması gerekmektedir. Elektrik dağıtım sistemi kayıpları en önemli konulardan biridir. Çünkü elektrik sistemlerindeki teknik kayıpların büyük bir kısmı dağıtım sistemlerinde oluşur.

Anahtar Kelimeler : Elektrik Kayıpları, Elektrik Dağıtım Sistemleri

ACKNOWLEDGMENTS

The author wishes to express his deepest gratitude to his supervisor Prof. Dr. Nevzat Özay for their guidance, advice, criticism, encouragements and insight throughout the research.

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CHAPTER 1

INTRODUCTION

The electrical energy is the most commonly used energy form in daily life. Most of the industrial apparatus need electrical power to operate as well as all equipments in the offices and houses. The electricity generation and consumption points are not generally at the same place. For this reason, it is necessary to transmit the generated electricity to the consumption areas via transmission and distribution networks. Due to the physical fact that all materials have resistance to the flow of electrons, the losses occur as heat energy while transmitting the electricity.

The bigger portion of the losses occur on the distribution systems because the voltage level of the distribution systems is lower and the amount of current flow is greater. The electricity is stolen in the distribution systems because the voltage level of transmission systems is not appropriate to operate the equipments. Therefore, it is extremely important to determine the actual losses in the distribution system to be able to have an idea about the amount of energy stolen.

Total consumption of Turkish Electricity Distribution Corporation (TEDAS) was 113,376,430 MWh and total losses were 20,180,642 MWh in the year 2005 according to the statistics published by TEDAS. Therefore, the distribution system loss ratio is 17.80%. This is much higher than the average of OECD Countries which is around 7.50%. The cost of this ten percent difference is 1.2 billion YTL, a considerable amount, regarding that the total income of TEDAS was 12 billion YTL in the year 2005.

Total net consumption of Turkey is 130,262,759 MWh in the year 2005 and the consumption of residential consumers is 30,934,976 MWh. The share of residential consumption in total consumption is 23.75%.

The main topic of this study is the distribution system losses of residential consumers. First of all, a residential area of Ankara is chosen instead of an imaginary area. A district of Yuzuncuyil was determined as the sample residential area which is located between Middle East Technical University and Cankaya University. After that, a typical daily load curve for a residential consumer is calculated with reasonable assumptions for Turkey. Next, the distribution system of the residential area is designed with three different approaches. Then, the distribution system losses are evaluated through these designed systems to realize the effects of system design. Three design alternatives are compared according to investment cost and the cost of losses. Finally, the effects of operating parameters such as power factor, the shape of daily load curve, voltage drops and unbalanced phase loads are investigated.

CHAPTER 2

LOAD

2.1. Introduction

A consumer purchases electricity as a means to some goals and needs. Different goal and needs are called end-uses. They span a wide range of applications such as lighting, heating, cooling etc. Each application, which requires electric power to function, is creating an electric load when it is activated.

The term load refers to the electrical demand of a device that draws power from the system for the purpose of accomplishing some task or converting that power to some other form of energy (light, heat). Electrical loads are usually rated by the level of power they require, measured in units of watts. Power ratings of loads refer to the device at a specific nominal voltage. Loads can be single phase or multi-phase. They can be modeled as a real (resistive only) or complex impedance (reactance).

Utility loads are usually classified by consumption purposes such as residential loads, commercial loads and industrial loads. Residential loads are combined loads of single houses. They are predominantly lighting, heating (water, space, cooking) and motors (refrigerator, washing machine, dishwasher). Commercial loads consist of office buildings, shopping malls and stores. They are primarily lighting, heating, air conditioning, office equipments such as computers, copying machines etc. Industrial loads consist of the same types of loads as commercial businesses plus large motors, production equipments etc.

The load is not constant but changes every time an electrical appliance is switched on or off. Some loads are seasonal, such as heating and air conditioning. Some loads depend on the sun, such as light bulbs. The load varies from minute to minute, from day to day, from season to season. Diagrams of load as a function of time are called as load curves. A load duration curve can be developed by sorting the demands in load curve in descending order.

Consumers within each class tend to be alike in usage patterns although every consumer has different electrical usage habits. Therefore, electric utilities use a typical daily load curve showing the load usage for a consumer in that class. These curves describe the amount of peak load per consumer, the time and duration of peak and the total energy. The electric utilities mostly use smooth, 24 hour load curves to represent the average behavior of each consumer in each class. This is common practice and results in customer class load curves. Actually, no residential consumer has a load curve like this average presentation because each home has slightly different appliances. Their peaks and the time of peaks are different than each other. For this reason, these individual peaks are not additive. As a result, the load curve needles usually interleave when these load curves are added. The load curve representing the sum of a group of residential consumers begins to take on the appearance of a smoother curve.

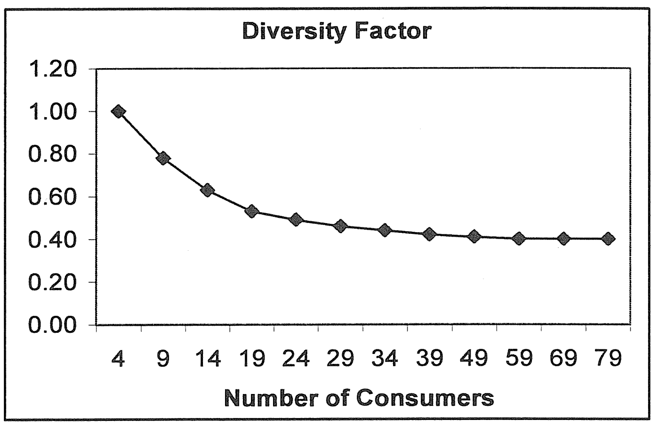
Individual household demand consists of load curves with erratic swings as major appliances switch on and off. Distribution system element that serves only one consumer serves a load like this. However, distribution element that serves large number of consumers, i.e. the distribution transformer, is looking at hundreds of appliances and at the same time. Peak load per consumer drops as more customers are added to a group. As a result, the group peak occurs when the combination of the individual load curves is at a maximum. This group peak load is substantially less than the sum of the individual peaks. This tendency, observed peak load per consumer to drop as the size of the consumer group being observed increases, is termed as diversity and is measured by the diversity factor. The diversity factor is the fraction of its individual peak that each consumer contributes to the group's peak and has a value between 0 and 1. Peak load per consumer is generally a strictly decreasing value as a function of the number of consumers in the group. The diversity behavior varies from one system to another. Diversity factor depends on the number of consumers, the consumption habits of the consumers etc. For this reason, diversity factors can not be calculated but they can be found by empirical means. The diversity factors for residential loads in Turkey are given in Table 2.1. An application of diversity factors is shown in Figure 2.1.

Peak period lasts longer for larger groups of consumers. The swinging load curve of a single customer may have a very high peak load but that peak lasts only a few minutes at any time, although it may repeat itself several times a day. In contrast, the load curve for hundred homes reaches its peak only once during a day but stays at or near peak much longer.

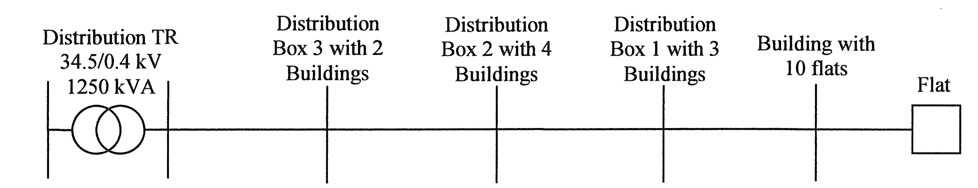
Sampling is used to obtain the load curves at different points in the electrical system. Sampling rate and sampling method both have a big impact on what load curve data will look like, the accuracy, and how appropriate they are for various planning purposes. Sampling rate refers to the frequency of measurement – the numbers of times per hour data are recorded. Sampling method refers to exactly what quantity is measured – instantaneous load or total energy used during each period.

Table 2.1 Diversity Factors

Number of Consumer		Diversity Factror
2	4	1.00
5	9	0.78
10	14	0.63
15	19	0.53
20	24	0.49
25	29	0.46
30	34	0.44
35	39	0.42
40	49	0.41
50	59	0.40
60	69	0.40
70	79	0.40



Most load metering equipment measures the energy used during each period of measurement (called demand sampling). As the sampling period of demand sampling is lengthened, the observed peak load drops. The sharp needle peaks are being averaged with all behavior over longer periods, reducing the measured peak demand. If the load is measured every fifteen minutes, the equipment measures and records the total energy used during each 15 minute period, and the resulting 96 point load curve gives the energy used during each quarter hour of day. This method of recording is sampling by integration – the equipment integrates the area under the load curve during each period and stores this area even if the actual load is varying up and down on a second by second basis.



# of Consumers:	470	90	70	30	10	1
Diversity Factor:	0.4	0.4	0.4	0.44	0.63	1
Diversified Total Demand:	940kVA	180kVA	140kVA	66kVA	31.5kVA	5kVA
Diversified Max. Demand Per Consumer:	2000 VA	2000VA	2000VA	2200VA	3150VA	5000VA

Figure 2.1 Application of Diversity Factors

2.2. Typical Daily Load Curve

The measured load curve of a certain consumer can not represent another consumer due to the different habits and life styles of the consumers. As a result, there is not such a daily load curve which will exactly represent all residential consumers. However, using a different daily load curve for each consumer is not practically applicable. In this case, a typical daily load curve is calculated and used in study.

The steps and the assumptions of the calculation procedure are given below.

- Make the list of electrical and electronics equipments commonly used in a house and find the electrical power ratings of these equipments from device technical data sheets.

- Make a time table which divides a day into 96 equal 15 minutes intervals. Make reasonable assumptions for the usage of equipments in a day.

- Calculate the total electrical power drawn in each 15 minutes period. The calculated 96 power data in watts form the daily load curve.

- Calculate the daily electrical energy consumption in kWh by multiplying the typical daily load curve values in watts by time values in hours.

- Calculate the load duration curve by rearranging the daily load curve.

The list of the electrically operated equipment in a typical house with their power ratings are given in Table 2.2. All electrical devices used in kitchen such as mixer, toaster etc are grouped as kitchen electrical devices. There is no air-conditioner in houses. The hot water at the bathroom is provided by electrical heaters. It is assumed that the house work is carried during the day time.

The utilization time of the equipment during a day and other calculation details are given in Appendix A. The calculated data of typical daily load curve for a residential is given in Table 2.3 and the daily load curve and the load duration curve for a residential consumer are shown in Figure 2.2 and Figure 2.3.

Table 2.2 List of Electrically Operated Equipment

Equipment	Power Rating (W)
Refrigerator	500
Oven	2,400
Dishwasher	3,200
Kitchen Electrical Devices	1,000
Washing Machine	3,000
Hair-dryer	1,200
Water Heater	2,000
Iron	1,200
Television	200
Audio System	100
Computer	100
Electrical Broom	1,000
Lighting	1,000

According to the calculated typical daily load curve, the peak value is 2,250 W. As a result, the maximum demand of consumer is 2,500 VA with a power factor of 0.9. Therefore, the diversified maximum demand at the distribution transformer is 1,000 VA with the diversity factor of 0.4. This result is compatible with the information gathered from the engineers of Baskent EDAS (electric utility of Ankara). The daily consumption of a residential consumer is 5,114 Wh and monthly consumption is 153.41 kWh according to the calculations. The monthly consumption is also compatible with real bills.

Table 2.3 Typical Daily Load Curve Data

Hour		Load Curve (W)	Hour		Load Curve (W)	Hour		Load Curve (W)
from	to		from	to		from	to	
00:00	00:15	29	08:00	08:15	104	16:00	16:15	269
00:15	00:30	29	08:15	08:30	104	16:15	16:30	149
00:30	00:45	29	08:30	08:45	78	16:30	16:45	269
00:45	01:00	29	08:45	09:00	38	16:45	17:00	149
01:00	01:15	29	09:00	09:15	38	17:00	17:15	129
01:15	01:30	29	09:15	09:30	138	17:15	17:30	169
01:30	01:45	29	09:30	09:45	138	17:30	17:45	213
01:45	02:00	29	09:45	10:00	129	17:45	18:00	313
02:00	02:15	29	10:00	10:15	129	18:00	18:15	1,003
02:15	02:30	29	10:15	10:30	67	***18:15***	***18:30***	***2,250***
02:30	02:45	29	10:30	10:45	427	18:30	18:45	1,103
02:45	03:00	29	10:45	11:00	307	18:45	19:00	473
03:00	03:15	29	11:00	11:15	427	19:00	19:15	252
03:15	03:30	29	11:15	11:30	269	19:15	19:30	252
03:30	03:45	29	11:30	11:45	94	19:30	19:45	252
03:45	04:00	29	11:45	12:00	94	19:45	20:00	252
04:00	04:15	29	12:00	12:15	94	20:00	20:15	252
04:15	04:30	29	12:15	12:30	196	20:15	20:30	352
04:30	04:45	29	12:30	12:45	224	20:30	20:45	281
04:45	05:00	29	12:45	13:00	166	20:45	21:00	281
05:00	05:15	29	13:00	13:15	94	21:00	21:15	311
05:15	05:30	29	13:15	13:30	29	21:15	21:30	1,231
05:30	05:45	29	13:30	13:45	29	21:30	21:45	501
05:45	06:00	29	13:45	14:00	29	21:45	22:00	432
06:00	06:15	29	14:00	14:15	29	22:00	22:15	432
06:15	06:30	29	14:15	14:30	29	22:15	22:30	112
06:30	06:45	29	14:30	14:45	1,229	22:30	22:45	82
06:45	07:00	29	14:45	15:00	629	22:45	23:00	82
07:00	07:15	84	15:00	15:15	367	23:00	23:15	44
07:15	07:30	436	15:15	15:30	367	23:15	23:30	44
07:30	07:45	194	15:30	15:45	329	23:30	23:45	44
07:45	08:00	172	15:45	16:00	329	23:45	00:00	29

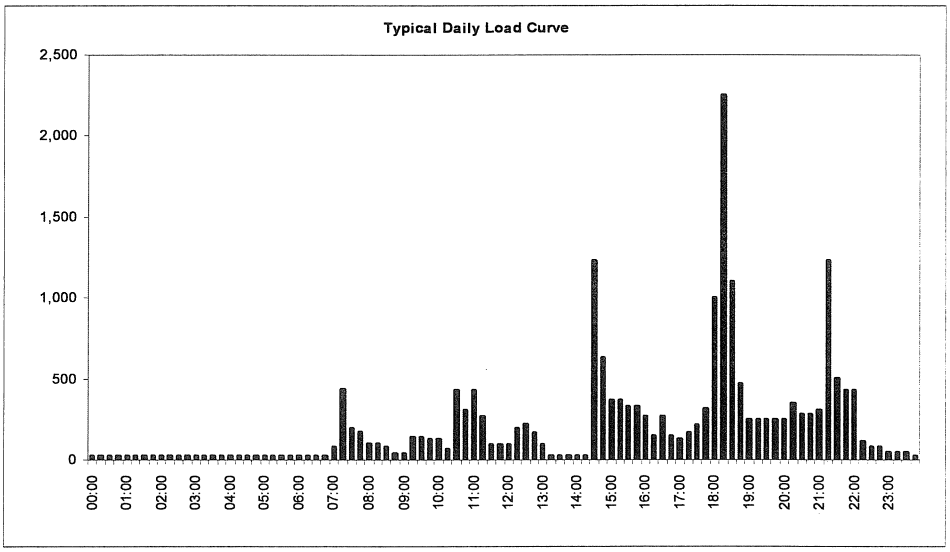


Figure 2.2 Typical Daily Load Curve

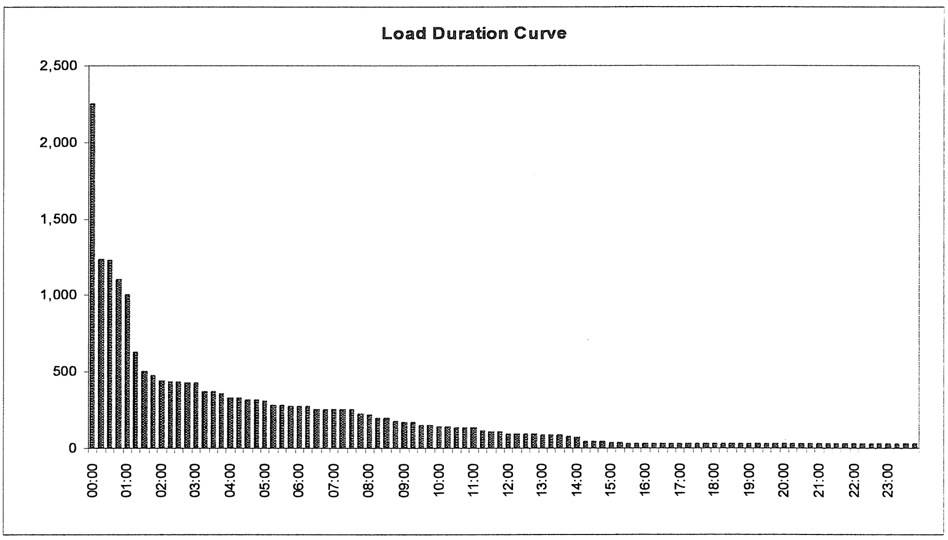


Figure 2.3 Load Duration Curve

2.3. Load Growth

Peak demand and energy usage within an electric utility system grow for only two reasons; customer additions and new uses of electricity. The peak load and annual energy sales increase with the increasing number of consumers. They increase also with the increasing consumption of consumers. Bulk of load growth on most power systems is due to changes in the number of consumers. However, changes in usage among existing consumers are also important.

Electric load growth in a power system appears different when viewed at the small area basis than when examined at the system level. When the annual consumption of Baskent EDAS is considered, it is a smooth growth curve. The energy consumption of Baskent EDAS customers is given in Table 2.4. There were 2,750,416 customers in the region of Baskent EDAS. The decrease in 2001 and 2002 is due to the economic crisis in Turkey and it is exceptional case for consumption growth.

When the service area is divided into small areas of only a kilometer square, something unusual happens to the smooth trend of growth. Each small area has a load history that looks something like as S curve rather than a smooth growth pattern. The S curve represents a history in which a brief period of rapid growth accounts for the majority of load. Every small area has a unique load growth history. Although they vary somewhat, the typical growth pattern follows an S curve.

Table 2.4 Electricity Consumption of Baskent EDAS

Years	Consumed Energy	
	kWh	Inc. (%)
1990	4,336,011,674	-
1991	4,649,723,995	7.24%
1992	4,978,222,120	7.06%
1993	5,365,666,780	7.78%
1994	5,626,931,007	4.87%
1995	5,951,814,925	5.77%
1996	6,314,336,748	6.09%
1997	6,859,076,502	8.63%
1998	7,373,053,413	7.49%
1999	7,685,088,926	4.23%
2000	8,187,180,540	6.53%
2001	7,750,842,354	-5.33%
2002	7,720,793,452	-0.39%
2003	8,003,729,053	3.66%
2004	8,360,861,866	4.46%
2005	9,045,415,652	8.19%

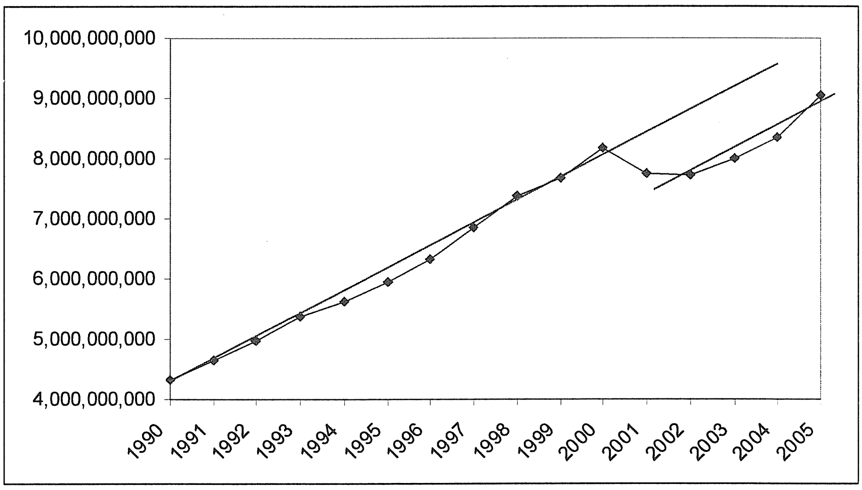


Figure 2.4 Electricity Consumption of Baskent EDAS

The S curve has three periods; dormant period, growth ramp and saturated period. In the dormant period, there is no load growth. There is a rapid increase during the growth ramp. Load growth may continue but at very low level compared to growth ramp in the saturated period. A typical S curve is shown in Figure 2.5.

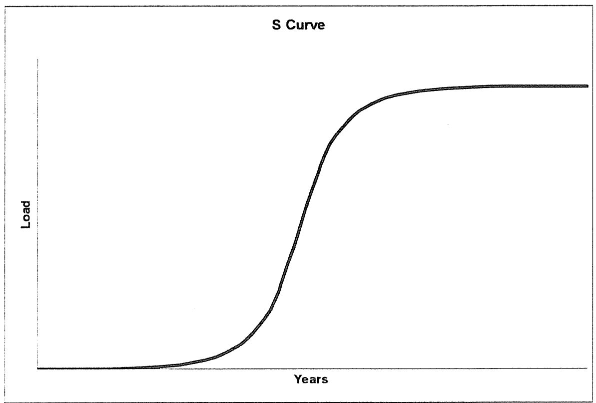


Figure 2.5 Typical S Curve

The sample area in this study is a small area. Therefore its load growth characteristic is an S curve. The sample area has been in existence for same time and for this reason, initial year can be assumed in the middle of growth ramp in the S curve. The data obtained from Baskent EDAS showed that the diversified maximum demand as seen from transformer terminals is around 1,000 VA in the sample area. It is estimated that the final value of diversified maximum demand will be 2,000 as compatible with developed countries. In this case, the diversified maximum demand in each year can be calculated by using S curve. The equation which fits with our initial and final points is as follows.

$$P(t) = 2{,}000\,(1 - e^{-0.34657359 \times (t+1)}) \qquad (2.1)$$

where

P (t): Diversified maximum demand in the year t
y: year in economic life time of the system

The diversified maximum demands calculated by using S curve formulation are given in Table 2.5 and the load growth curve is given in Figure 2.6.

Table 2.5 Diversified Maximum Demand in Years

Year	Div. Max. Demand (VA)	Increase Ratio (%)	Year	Div. Max. Demand (VA)	Increase Ratio (%)
1	1,000.00	0.00%	16	1,994.48	0.11%
2	1,292.89	29.29%	17	1,996.09	0.08%
3	1,500.00	16.02%	18	1,997.24	0.06%
4	1,646.45	9.76%	19	1,998.05	0.04%
5	1,750.00	6.29%	20	1,998.62	0.03%
6	1,823.22	4.18%	21	1,999.02	0.02%
7	1,875.00	2.84%	22	1,999.31	0.01%
8	1,911.61	1.95%	23	1,999.51	0.01%
9	1,937.50	1.35%	24	1,999.65	0.01%
10	1,955.81	0.94%	25	1,999.76	0.01%
11	1,968.75	0.66%	26	1,999.83	0.00%
12	1,977.90	0.46%	27	1,999.88	0.00%
13	1,984.37	0.33%	28	1,999.91	0.00%
14	1,988.95	0.23%	29	1,999.94	0.00%
15	1,992.19	0.16%	30	1,999.96	0.00%

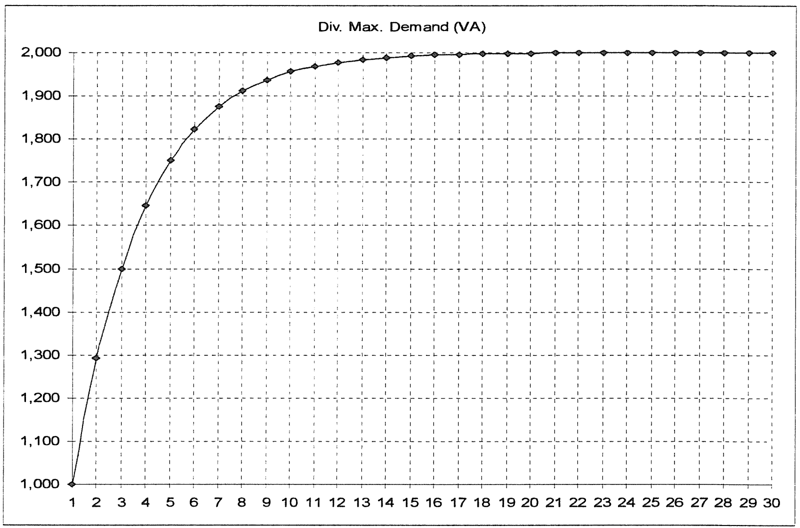


Figure 2.6 Load Growth Curve

CHAPTER 3

DESIGN

3.1. Introduction

In this chapter, the low voltage distribution system of a residential area is designed with distribution transformers having different ratings. The sample residential area is between Middle East Technical University and Cankaya University in Yuzuncuyil.

3.2. Elements of Distribution Systems

Modern power grids are extremely complex and widespread. They are usually divided into three segments which are generation, transmission and distribution. The figure 3.1 illustrates some of the major components in these divisions.

The transmission and distribution system delivers electricity from electrical power plants to residential, commercial, and industrial facilities. The electricity first goes to a transformer at the power plant that steps up the voltage for distribution through extra-high voltage (EHV) transmission lines. High voltage transmission lines transmit electricity long distances to a substation. At transmission substations a reduction in voltage occurs for distribution to other points in the system through high voltage (HV) transmission lines. Further voltage step downs for commercial and residential customers take place at distribution substations, which connect to the primary distribution network.

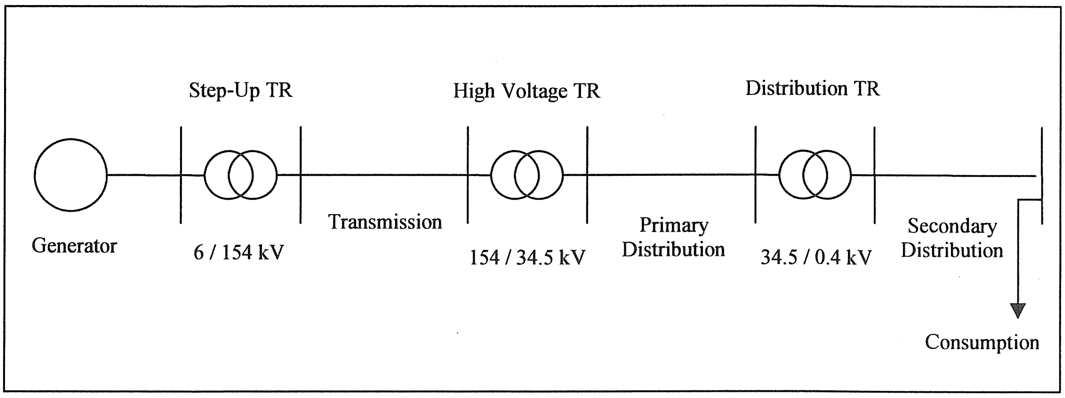


Figure 3.1 Major Components of an Electricity System

The distribution system is a set of facilities for the distribution of electricity from the transmission system to end-users. The differences between metered loads at the wholesale supply point and the retail supply point called as the distribution system losses.

The distribution system is commonly broken down into the following three components:

i. Distribution Substations HV (380, 154 kV) / MV (34.5 kV)

ii. Primary Distribution

  a. Primary Feeders MV (34.5 kV)

  b. Transformer Substations MV (34.5 kV) / MV (15.0, 10.5, 6.3 kV)

  c. Secondary Feeders MV (15.0, 10.5, 6.3 kV)

iii. Secondary Distribution

  a. Distribution Transformers MV (15.0, 10.5, 6.3 kV) / LV (0.4 kV)

  b. Load Feeders LV (0.4 kV)

Distribution Substations: The distribution system is fed through distribution substations. These substations consist of an almost infinite number of designs based on considerations such as "load density, voltage levels, land availability, reliability requirements, load growth, voltage drop, emergency conditions, cost and losses etc". The voltage of the high side bus can be 380 kV, 154 kV or 66 kV in Turkish Electricity System. Preferred high side voltage level is 154 kV because this voltage level is usually high enough to maintain a stiff enough source and low enough to alleviate the cost associated with high voltage side equipments. The average substations consist of two to four transformers with a maximum rating of 100 MVA.

Primary Distribution: It is the part of the system between the distribution substation and the distribution transformers, known also as the medium voltage system. Previously, this system composed of two voltage levels; a voltage level of 6.3 – 15.0 kV, and an overlay of 34.5 kV. However likely, because of high investment cost and losses, only 34.5 kV feeders are used and the lower voltage levels are upgraded gradually. The 34.5 kV systems can be designed in different ways.

- *Radial System:* There is only one supply path available to the distribution transformers. The major disadvantage is that any problem usually leaves a number of customers out of service until the problem is solved. The major advantages of the radial layout are that it is simpler and more economical to install than other types of layouts.

- *Loop Arrangement:* A great improvement is obtained by arranging a loop, which provides two-way feed at each transformer. Any section of the primary can be isolated without interruption and primary faults are reduced in duration to the time required to locate a fault and do the necessary switching to restore service. The cable in each half of the loop must have capacity enough to carry the entire load. The loop layout is very reliable and expensive.

- *Networks:* They are designed to provide very reliable service to areas with dense loads such as downtown and suburban business residential areas containing many multi-story buildings.

Secondary Distribution: The purpose of the distribution transformer is to step-down the primary voltage to a level where it can be utilized by the customers. 3-phase commercial distribution transformers range in size anywhere from about 25 kVA to 2500 kVA. The secondary voltage level in Turkey for residential service is 0.4 kV.

The main elements of system are meters, cables and transformers. The single line diagram of the system designed in this study is shown in Figure 3.2.

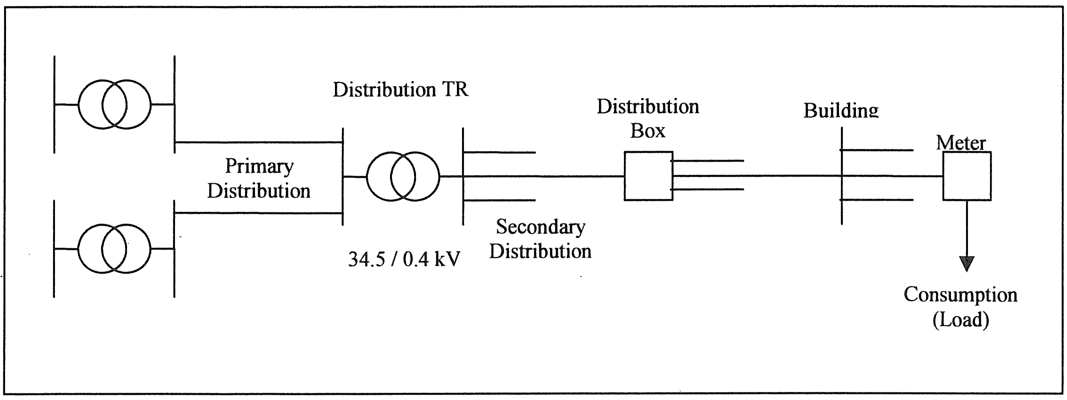


Figure 3.2 Single Line Diagram of Designed System

3.2.1. Meters

Power metering equipment records the amount of power used in a particular area, sent down a particular line and used in a particular structure. Metering equipment provides power use information for planning for future needs from power use trends and off course billing for revenue. Power meters use a current coil and a potential coil to turn and an induction disc, which then turns accumulating devices. The disc rotation is proportional to the power passing through the metered line. Electronic circuitry with microprocessor control can perform the same function and also transmit the accumulated power use data to a central point or record it in a digital memory for retrieval at the meter side. Low voltage meters can be hooked directly to the monitored line voltage and current, but meters for station monitoring and large commercial and industrial customers must be fed through instrument transformers.

3.2.2. Lines

Electrical power distribution lines connect the distribution substation to the ultimate customer. They must be reliable, low in maintenance, economical and long lasting. Distribution lines are normally constructed along sidewalks on streets.

The only two metals that are cost effective and low enough in resistivity are copper and aluminum. Copper is so much heavier than aluminum that is used primarily in insulated wires and cables. The tensile strength of pure aluminum is not high enough for most applications so aluminum alloys or steel reinforced aluminum alloys are used.

The dc resistance of a conductor is inversely proportional to the area of a conductor, doubling the area halves the resistance. Temperature and frequency change the resistance of a conductor. A hotter conductor provides more resistance to the flow of current.

Distribution systems are usually designated as either overhead or underground. Overhead distribution consists of conductors, structures to support conductors and insulators. Underground systems consist of ducts, vaults and cables.

- *Overhead Systems:* Along streets, alleys, through woods and in backyards many of the distribution lines that feed customers are overhead structures. The overhead structures consist of wood or steel poles, insulator supports and miscellaneous hardware for device and conductor attachment.

- *Underground Systems:* Underground distribution is much more hidden from view than overhead circuits and is more reliable. Underground distribution systems consist of buried ducts, vaults and cables. An underground distribution system is very expensive compared to an equivalent overhead system and has a shorter life span. Underground systems suffer fewer outages because they are protected from storms, lightning and vehicle accidents. Underground cables normally use stranded copper instead of aluminum for conductors. The lower resistivity of copper helps to keep losses lower.

- *Comparison of Overhead and Underground:* Both designs have advantages. The major advantage of overhead circuits is cost. An underground circuit typically costs anywhere from 1 to 2.5 times the equivalent overhead circuit. The major drive from overhead distribution to underground distribution was primarily a response to environmental pressures. Table 3.1 shows the advantages of both.

Table 3.1 Comparison of Overhead and Underground Lines

Overhead	Underground
- Significantly less cost.	- Much less visual clutter.
- 30 to 50 years vs. 20 to 40 for new underground works.	- Less chance for public contact.
- Shorter outage durations because of faster fault finding and faster repair.	- Significantly fewer short and long-duration interruptions.
- Overhead circuits can more readily withstand overloads.	- Less voltage drops because reactance is lower.

3.2.3. Transformers

Transformers are a crucial link in the electric power distribution system. They convert electricity from the high voltage levels in utility transmission systems to voltages that can safely be used in businesses and homes. The distribution transformer often provides a local grounding reference.

Transformers consist of two primary components: a core made of magnetically permeable material and a winding made of a low resistance material such as copper or aluminum. Liquid insulation material or air surrounds the transformer core and conductors to cool and electrically insulate the transformer. There are three sources of losses in a transformer: copper, hysteresis and eddy current. They use real power and reduce transformer efficiency.

Copper losses are caused by the current flowing through the winding resistance. Skin effect causes the ac resistance of the transformer windings to increase with frequency, so copper losses increase with frequency if the winding current remains constant. Proper sizing of the winding wire minimize copper losses.

Hysteresis losses are the result of the energy needed to magnetize the core first in one direction and then the other as the applied ac voltage reverses in polarity. The magnetic domains must form in one direction, and then in the other. Hysteresis losses increase with frequency because the domains must be reversed more frequently. These losses are minimized by the proper choice of magnetic material. A magnetic material has been developed that is amorphous in structure instead of having the small crystalline grain structure of most current magnetic materials. This means the magnetic domains are almost atomic in size and require very little energy reverse. Due to their relatively high cost, the amorphous magnetic materials are not currently in wide use. The losses occurring with the amorphous magnetic steel are one-third of those occurring with conventional grain oriented magnetic steel. Hysteresis losses are a function of the volume of the core, the frequency and the maximum flux density.

Eddy current is induced in metal near a magnetic field. If the field surrounds the metal object, the induced current will be a loop at the right angle to the flux. The core of a transformer is ideally positioned with respect to the windings for eddy current to be induced in it. The laminations break the core into many small thin pieces of metal, thereby reducing the voltage that is induced to drive eddy currents in the core and increasing the resistance through which eddy currents must flow because the cross-sectional area of each lamination is small. The eddy current losses are a function of core volume, frequency, flux density, lamination thickness and resistivity of the core material.

Load losses are copper losses and no-load losses are the sum of hysteresis losses and eddy losses. They are continuous losses of a transformer, regardless of load. Load losses, no-load losses and purchase price are all interrelated. Approaches to reduce the load losses tend to increase no-load losses and vice versa. Table 3.2 shows ways to decrease transformer losses.

Many utilities evaluate the total lifetime cost of distribution transformers, accounting for the initial purchase price and the cost of losses over the life of the transformer (the total owning cost). Utilities typically assign an equivalent present value for the cost of no-load losses and another for the cost of load losses.

Table 3.2 Ways to Decrease Transformer Losses

Changes	No-Load Losses	Load Losses	Cost
- Use lower-loss core materials	lower	same	higher
- Decrease flux density by:			
increasing core cross-sectional area	lower	higher	higher
decreasing volts/turn	lower	higher	higher
- Decrease flux path length by decreasing conductor cross-sectional area	lower	higher	lower
- Use lower-loss conductor materials	same	lower	higher
- Decrease current density by increasing conductor cross-sectional area	higher	lower	higher
- Decrease current path length by:			
decreasing core cross-sectional area	higher	lower	lower
increasing volts/turn	higher	lower	higher

The capacities of distribution transformers in the market are varying from 25 kVA to 2500 kVA in Turkey. The list of the transformers and their some parameters are shown in Table 3.3.

Table 3.3 Transformers in the Market (Primary Voltage is up to 36 kV)

Rating (kVA)	Losses		%UK	Cos φ=1	
	No-Load (W)	Load (75 °C) (W)		Efficiency (%)	Voltage Drop (%)
50	230	1050	4,5	97,47	2,26
100	380	2100	4,5	97,65	2,06
125	420	2400	4,5	98,79	2,00
160	480	2800	4,5	98,99	1,83
250	700	3500	4,5	98,13	1,70
400	900	5850	4,5	98,34	1,55
500	1250	6750	4,5	98,42	1,44
630	1350	8000	4,5	98,53	1,39
800	1520	9700	6	98,61	1,38
1000	1600	12200	6	98,63	1,36
1250	1950	14000	6	98,74	1,29
1600	2350	16500	6	98,80	1,20
2000	3000	21000	6	99,85	1,20
2500	3800	24000	6	99,85	1,11

3.3. Losses on Distribution Systems

Energy losses occur in the process of supplying electricity to consumers due to technical and commercial losses. The losses in any system would depend on the pattern of energy use, intensity of load demand, load density, and capability and configuration of distribution system that vary for various system elements. The technical losses are due to energy dissipated in the conductors and equipment used for distribution of power. The technical losses are inherent in a system and can be reduced to a minimum level. System losses are generally defined as a percentage of the difference between total energy input to the network and sales to all customers. The recorded losses can be broken down into three main groups, load losses on series circuits, no-load losses on shunt circuits and non-technical losses.

Load losses: These occur mainly in lines and cables and in the copper parts of transformers and vary in the amount of electricity that is transported through the equipment. They are proportional to the square of the current. Load losses can be influenced in a number of ways:

- Increasing the cross sectional area of lines and cables for a given load will lower losses but there will be a trade-off between cost of losses and cost of capital expenditure.

- Moving to higher voltages reduces current and therefore losses in the networks.

- There is scope for reducing losses by reconfiguring the network, for example by providing more direct lines to where demand is currently situated.

- Reducing peaks in demand can reduce losses. An additional demand of 1 GW in peak times will result in a greater increase in losses than 1 GW in off-peak periods.

- Balancing 3 phase loads periodically throughout a network can reduce losses significantly.

No-Load Losses: These occur mainly in the transformer cores and do not vary according to electrical current. No-load losses on a network can also be influenced in a number of ways, including:

- The level of fixed losses in a transformer is largely dependent on the quantity and quality of the raw material in the core. Therefore higher quality materials will lead to lower losses.

- Eliminating 10.5 kV and less distribution levels and moving to 34.5 kV voltage levels can reduce losses. Switching off transformers in periods of low demand can also lead to lower losses.

Non-Technical Losses: These comprise of units that are delivered and consumed but for some reasons are not recorded as sales. Non technical losses can be reduced in a number of ways, such as:

- The introduction of modern electronic meters can reduce the likelihood of meter errors.

- For practical reasons, some electrical installations, such as street lighting are not metered. Improvements in these areas will help reduce losses.

Theft is a common problem of electric utilities. Theft ratios are higher in developing countries than developed countries because the cost of electricity is a much higher portion of a person's income. Although the main reason for preventing power theft is revenue protection, there are other reasons, such that customers tampering with metering equipments are prone to electrocution. In many areas, the investigations to detect the theft rely on human resources. However, various instruments such as meter seals, security rings, controlling electronic devices, strong meter cases, computer programs can help to investigate theft. Moreover, investigating the reasons of theft and removing the reasons can be one of the means. In addition to that, giving information to people about the danger of tampering electrical devices and extra costs due to the theft by using press and other media can be an effective way. It is important to stress that the highest financial loss came from electrical energy theft by industrial and commercial customers. Once theft has been detected, the actions a utility can take vary. Utilities decide whether to simply recover revenue and other costs relating to the theft or seek criminal prosecution for the thieves. In many places, thieves can be prosecuted by the law.

3.4. Design Parameters

In the sample area, there are 940 houses. The medium voltage level of existing distribution system of the sample area is 34.5 kV. The plan of the sample residential area is given in Figure 3.3. 2,000 VA is used as diversified maximum demand in design. The currently valid planning criterion of TEDAS is also 2000 VA. This value is also compatible with the applications in Europe. With the diversified maximum demand per consumer taken as 2000 VA, the maximum demand of the sample residential area is

$$2{,}000 \text{ VA} \times 940 \text{ (consumers)} = 1{,}880 \text{ kVA} \tag{3.1}$$

Assuming that the transformers are loaded up to 80% of the rating,

$$1{,}880 \text{ kVA} / 0.8 = 2{,}350 \text{ kVA} \tag{3.2}$$

In order to study the effects of transformer ratings in the losses, 2,350 kVA of transformer capacity can be met with either 2x1250 kVA, or 4x630 kVA, or 8x315 kVA with the standard values. These are used in the design alternatives.

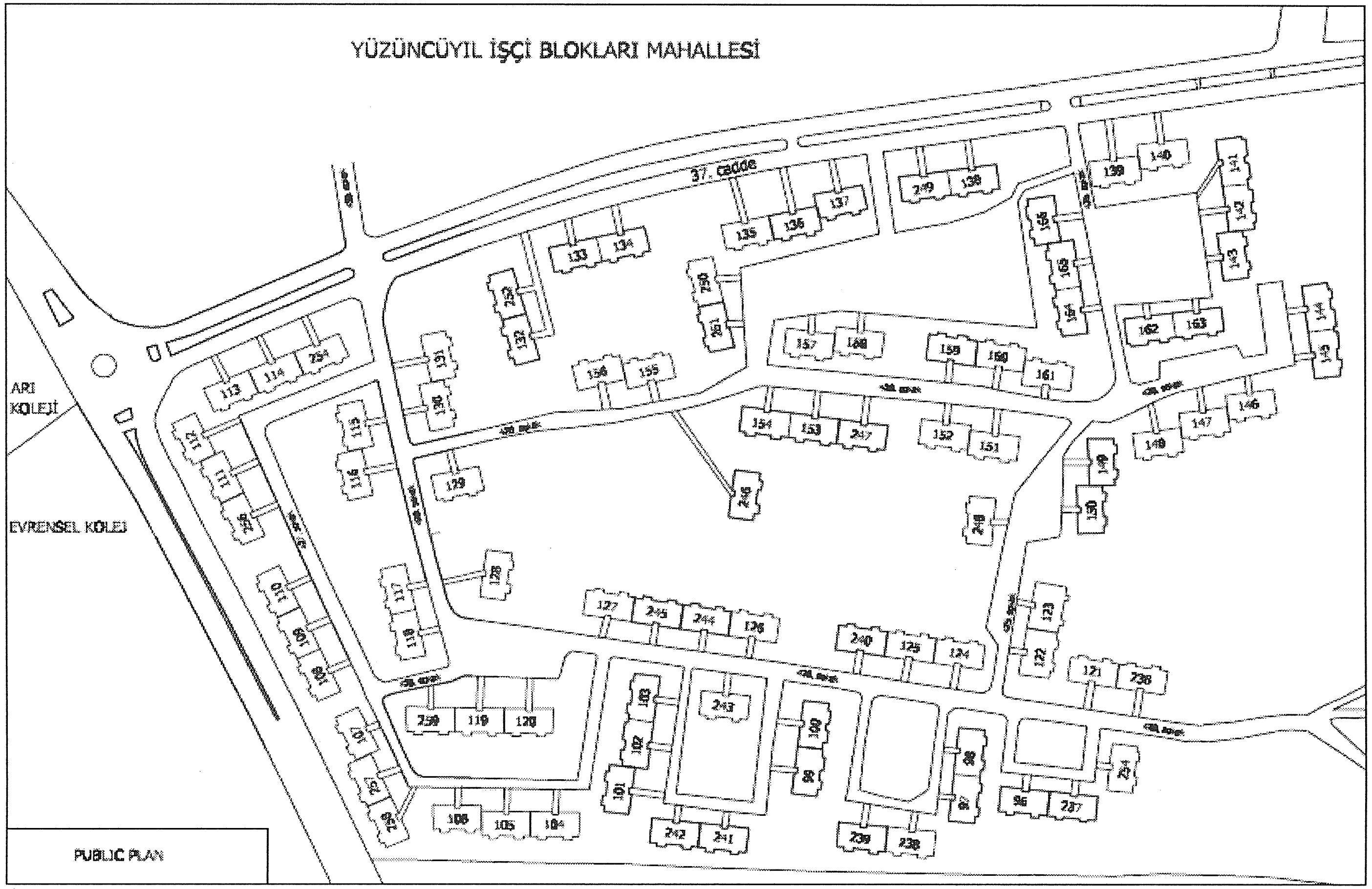


Figure 3.3 Plan of Sample Area

The criterions of the design study are listed below:

- The number of outgoing feeders is at most 8 for distribution transformers and 6 for distribution boxes.
- The locations of distribution boxes are not changed in all design alternatives.
- The maximum allowed voltage drop between transformers and buildings is 5%.
- The cables between transformers and distribution boxes are selected according to current carrying capacity. If the voltage drop is higher than the allowed limit, then the cable is replaced with higher cross-section cable.
- The cross-section of cables is 150 mm^2 at most due to the physical difficulties in installation.
- The power factor of residential consumers is 0.9.
- The medium voltage level is 34.5 kV. It is the same with the existing system.
- The cables between 34.5 kV transformers are chosen as 3x95 mm^2 as compatible with the existing cables of ring system in the sample area.

3.5. System between Buildings and Distribution Boxes

The locations of distribution boxes are the same in all design alternatives. Then the system between distribution boxes and buildings is designed once and used in all design alternatives. The detailed design calculations are given in Appendix B.

The diversified maximum demand is 2,000 VA in this study. Therefore, the maximum demand of a residential consumer is 5,000 VA with the diversity factor of 0.4. The maximum current drawn by a consumer can be calculated as follows.

$$I_{max} = S / (\sqrt{3} \times V) \tag{3.3}$$

$$I_{max} = 5000 \text{ VA} / (\sqrt{3} \times 380) = 7.6 \text{ A} \tag{3.4}$$

There are 10 flats in the sample buildings of the sample residential area. In this case, the maximum current drawn by a sample building is 47.86 A with the diversity factor of 0.63. Therefore, the supply cables are (4x10) mm^2.

3.6. System between Distribution Boxes and Transformers

Three different designs are made by using 2x1250 kVA, 4x630 kVA and 8x315 kVA transformers.

In Design Alternative – 1, two 1250 kVA transformers are used and they are named as TR-1 and TR-2. These transformers are connected to the existing medium voltage system through 274.4 meters of cable. The detailed design calculations are given in Appendix B. The drawing of Design Alternative – 1 is shown in Figure 3.4. 470 of consumers are fed from TR-1 and other consumers are fed from TR-2. Both transformers have seven lines to feed distribution boxes.

In Design Alternative – 2, four 630 kVA transformers are used which are named as TR-1, TR-2, TR-3 and TR-4. The detailed design calculations are given in Appendix B. The drawing of Design Alternative – 2 is shown in Figure 3.5. 220 of consumers are fed from TR-1, 250 consumers from TR-2, 260 consumers from TR-3 and 210 consumers from TR-4.

In Design Alternative – 3, eight 315 kVA transformers are used and they are named as TR-1, TR-2, TR-3, TR-4, TR-5, TR-6, TR-7 and TR-8. The detailed design calculations are given in Appendix B. The drawing of Design Alternative – 3 is shown in Figure 3.6. 130 of consumers are fed from TR-1, 120 consumers from TR-2, 120 consumers from TR-3, 120 consumers from TR-4, 120 consumers from TR-5, 100 consumers from TR-6, 130 consumers from TR-7 and 100 consumers from TR-8.

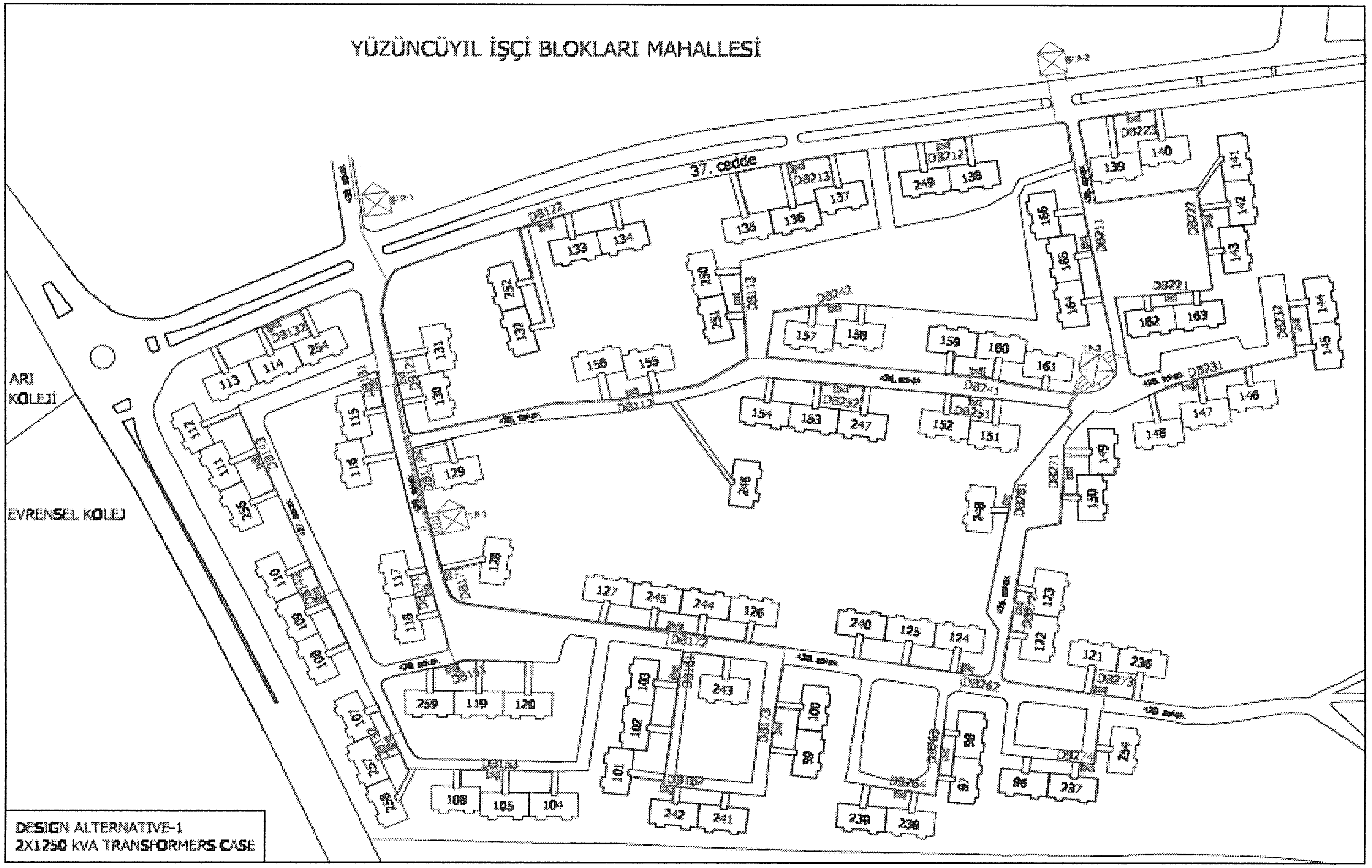


Figure 3.4 Design Alternative – 1

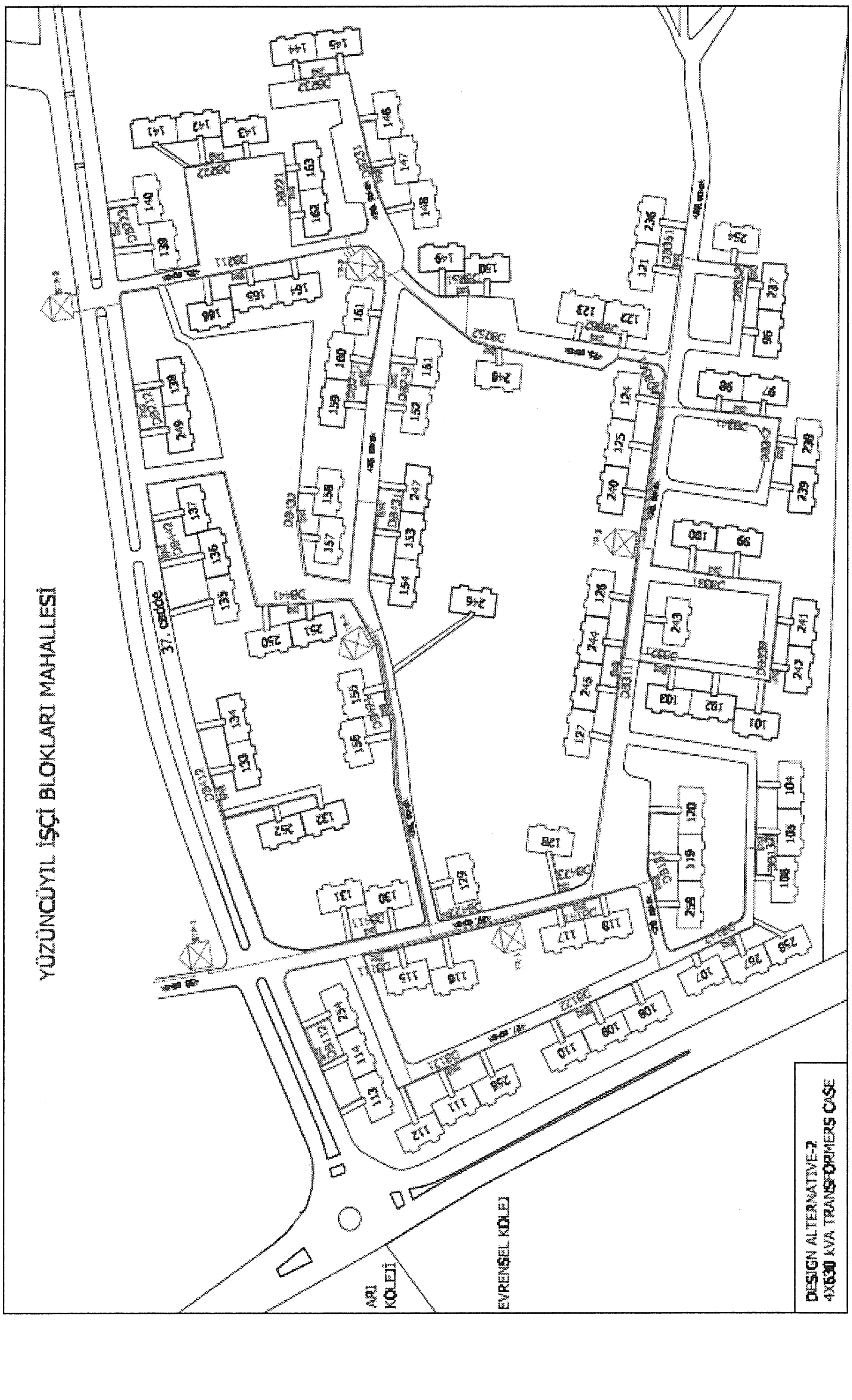


Figure 3.5 Design Alternative – 2

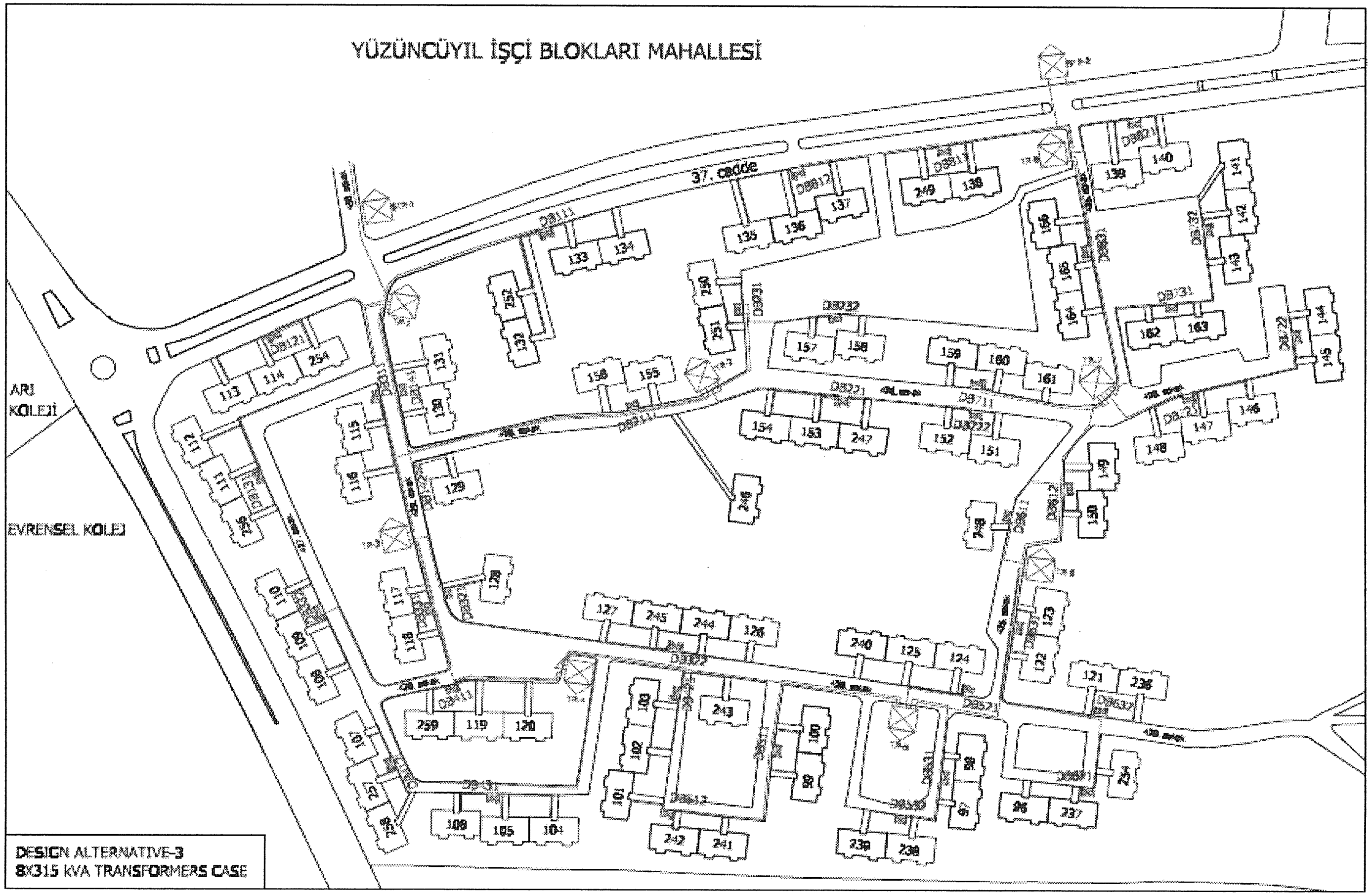


Figure 3.6 Design Alternative – 3

3.7. Comparison of Design Alternatives

The main criterion of design is to provide the required power to consumers at proper voltage level. For this reason, the maximum voltage drops are almost the same in all deign alternatives. The maximum and minimum current values are higher in Design Alternative – 1. The comparison according to electrical quantities is given in Table 3.4.

Table 3.4 Comparison According to Electrical Quantities

			Design Alt – 1	Design Alt – 2	Design Alt – 3
Current (A)	max	between transformers and distribution boxes	273.48	212.71	182.32
	min	between transformers and distribution boxes	151.93	100.28	74.45
Voltage Drop (V)	max	between transformers and buildings	11.53 (4.99%)	11.51 (4.98%)	11.56 (5.00%)
	min	between transformers and buildings	2.98 (1.29%)	3.78 (1.64%)	3.63 (1.57%)

Amounts of the different equipment used in design alternatives are listed in Table 3.5. The length of the medium voltage level cables is the shortest in Design Alternative – 1. However the length of low voltage level cables is the longest in this case.

The first investment costs of design alternatives are given in Table 3.6. The source of the unit costs is the cost reference book published by Turkish

Electricity Distribution Authority (TEDAS) in 2006. The market research shows that it is possible to take %20 - %40 discount due to the competition while buying the equipments in the market.

Table 3.5 Comparison According to Equipments

Name of Equipment	Design Alt - 1	Design Alt - 2	Design Alt - 3
	Unit	Unit	Unit
34.5/0.4 kV 1250 kVA transformer	2	0	0
34.5/0.4 kV 630 kVA transformer	0	4	0
34.5/0.4 kV 315 kVA transformer	0	0	8
34.5 kV Cable – (3x95) mm^2	590.30	758.00	969.00
Distribution Boxes	38	38	38
0.4 kV Cable – ((3x95)+(1x50)) mm^2	1,288.24	212.60	0.00
0.4 kV Cable – ((3x70)+(1x35)) mm^2	391.82	404.75	0.00
0.4 kV Cable – ((3x50)+(1x25)) mm^2	349.24	483.25	0.00
0.4 kV Cable – ((3x35)+(1x16)) mm^2	492.22	572.63	732.70
0.4 kV Cable – ((3x25)+(1x16)) mm^2	111.13	617.67	623.23
0.4 kV Cable – ((3x16)+(1x10)) mm^2	0.00	270.18	761.98
0.4 kV Cable – (4x10) mm2	2,062.12	2,062.12	2,062.12

Although the cable costs of Design Alternative – 1 is higher than others, the total cost of it is lower because of the biggest share of total cost is due to transformers. For this reason, if the number of transformers is less then the total cost is less. Moreover, when the cost of transformer land is calculated, the cost is increase with the number of transformers because the land is too expensive in big cities. It is a good strategy to use less number of transformers to be able to decrease the first investment cost.

Table 3.6 Comparison According to First Investment Cost

Cost (YTL)	Design Alt - 1		Design Alt - 2		Design Alt - 3	
	Cost	Share	Cost	Share	Cost	Share
Transformers	217,975.40	47.91%	396,078.56	63.55%	735,313.04	76.97%
Distribution Boxes	38,165.30	8.39%	38,165.30	6.12%	38,165.30	4.00%
MV Cables	52,372.60	11.51%	67,251.28	10.79%	85,971.62	9.00%
LV Cables	146,454.51	32.19%	121,732.79	19.53%	95,846.78	10.03%
Total	***454,967.81***		***623,227.93***		***955,296.74***	

CHAPTER 4

LOSSES

4.1. Introduction

In this chapter, the losses of the designed low voltage distribution system are calculated and three design alternatives are compared regarding the total system losses and total costs.

4.2. Losses on Meters

Meters need two parameters to determine the electrical energy coming from the network. Two sampling circuits are used to determine voltage and current parameters. Both sampling circuits cause electrical power losses.

Some metering devices for residential consumers are listed in Table 4.1. According to Table 4.1, the power losses on voltage sampling circuit are changing between 0.9W and 1.4W for electromechanical meters. For electronic meters it is between 1W and 2W. Before the electronic meters became obligatory, electromechanical meters were used. Most of the residential consumers in Turkey are still using electromechanical meters.

Electrical Metering Devices Regulation (by Industrial and Trade Ministry – 15 February 2001) numbered as 24319 defines the standards for electronic metering devices as follows:

i. Maximum power loss on the voltage sampling circuit is 2W or 10VA.
ii. Maximum power loss on the current sampling circuit is 2.5VA for the meters up to 30A operating current. It is 5VA for the meters with operating currents above 30A.

Table 4.1 Some Meters in the Market

Firm	Type	Power Losses			
		Voltage Circuit		Current Circuit	
		W	VA	W	VA
MAKEL	Electromechanical	1.4			1.0
KOHLER	Electromechanical	0.9	4.1		1.4
ISKRAEMECO	Electromechanical	1.0	3.9	0.18	0.35
MAKEL	Electronic	2.0	10.0		4.0
KOHLER	Electronic	2.0	10.0		2.5
ISKRAEMECO	Electronic	2.0	10.0		0.5
BAYLAN	Electronic	2.0	10.0		1.0
ENTES	Electronic	2.0	10.0		2.5
MANAS	Electronic	1.0	2.0		
KAAN	Electronic	2.0	7.5		0.1

When Table 4.1 is examined, it is obvious that the most of the companies give the standard values as technical data for electronic meters. In this study, the realistic values (1W for voltage circuit and 1VA for current circuit) in the technical data sheets are used instead of the standard values (2W for voltage circuit and 2.5VA for current circuit) guarantied by regulation. For electromechanical meters, typical values obtained from KOHLER Company technical data sheets are used because Kohler Company was one of the main suppliers of metering devices in Turkey before 2001. The regulation has been valid since the beginning of the year 2002. After this regulation, the usage of electronic meter became obligatory. For this reason, the meters installed after this date is electronic meters and the meters installed previously are electromechanical meters in Turkey.

The power losses on voltage sampling circuit are independent from the load current and it is constant whenever the meter is online. To calculate the daily electrical energy losses in Wh due to the electrical power loss on voltage sampling circuit, the electrical power loss in W on voltage sampling circuit is multiplied by 24 hours.

The power losses on current sampling circuit are changing with the load current. While calculating the electrical energy loss on current sampling circuit, the daily load curve must be used. The loss values given in the technical data sheets are at the rated current of 10 A. Change in power losses is proportional with the square of change in flowing current. The power factor for electromechanical meters is taken as 0.85 and 0.98 for electronic meters.

The power losses on current sampling circuit are calculated in Appendix C. The daily electrical energy losses on the meter of a residential consumer are shown in Table 4.2.

Table 4.2 Daily Losses on a Meter

Year	Meter Type	Power Losses		Daily Energy Losses		
		Voltage Circuit (W)	Current Circuit (VA)	Voltage Circuit (Wh)	Current Circuit (Wh)	Total (Wh)
First	Electromechanical	0.9	1.4	21.60	1.09	22.69
	Electronic	1.0	1.0	24.00	0.89	24.89
20th	Electromechanical	0.9	1.4	21.60	4.36	25.96
	Electronic	1.0	1.0	24.00	3.56	27.56

The losses on the voltage sampling circuit are much higher than the current sampling circuit. The daily consumption of a residential consumer is 10,228 Wh in the 20th year. Then, the ratio of metering devices losses is 0.25% for electromechanical meters and 0.27% for electronic meters. As a result, the daily losses on electronic meters and electromechanical meters are very close to each other. If the meters of other companies were taken as reference, the results will be different but they still will be very close because all companies use same technology and similar designs.

Table 4.3 shows the number of consumers before the metering devices regulation at the end of 2001 and the number of consumers at the end of 2005. This information is published by Turkish Electricity Distribution Company (TEDAS).

Table 4.3 Number of Consumers in Turkey

Year	Residential	Other	Total
2001	20,669,246	4,137,034	24,806,280
2005	23,085,372	4,887,231	27,972,603
Difference	2,416,126	750,197	3,166,123

The total annual energy losses due to the metering devices of residential consumers in Turkey are calculated and are given in Table 4.4.

Table 4.4 Losses on Meters of Residential Consumers in Turkey

Meter Type	Number of Meters	Daily Losses per Consumer (Wh)	Daily Losses (kWh)	Annual Losses (kWh)
Electromechanical	20,669,246	25.96	536,574	195,849,374
Electronic	2,416,126	27.56	66,588	24,304,778
Total	23,085,372	-	603,162	220,154,151

Electrical energy consumption of TEDAS customers was nearly 113.4 billion kWh in 2005. According the result of calculations made by using the typical daily load curve, the electrical energy losses in metering devices is 220 million kWh. In this case, the share of energy losses on metering devices is 0.194%.

The unit price of the electrical energy is 12.8 YKr/kWh excluding taxes for residential consumers and it is 16.128 YKr/kWh including 5% municipality consumption tax, 2% commission of TRT (Turkish Radio Television Corporation) and 18% value added tax. Therefore, the cost of lost energy is 35.5 million YTL.

The losses on electronic and electromechanical meters are very close to each others. As a result of meetings with a certain manufacturer, it is concluded that the losses on electronic meters can be decreased to half by effective design and proper circuit elements. In this case, the amount of saved money is approximately 18 million YTL which is sufficient to construct a 18 MW natural gas power plant.

4.3. Losses on Cables

The cable is the link between the meters and the transformers. The losses on the cables are examined in three parts: the cables within the buildings, the cables between buildings and distribution boxes, the cables between distribution boxes and transformers.

4.3.1. Losses on the Cables within the Buildings

Metering devices were installed previously on the entrance of the flats instead of the entrance of the building. In this application, the power losses due to the resistance of cables within the building were absorbed by the system operator. They were added to total system losses and their cost was paid by all consumers. These days, the metering devices are moved from the entrance of flats to the entrance of building by the regulation. As a result of new application, the power losses due to the resistance of cables within the building are charged to the consumers. In this case, the cost of the power losses is paid by the source of the losses.

In this study, a building with five floors and two flats on each floor is taken as the sample building. The total length of cables within the building can be calculated as shown in Table 4.5. The residential consumers are fed by single phase system in the sample building. The cables with 4 mm^2 cross-section are used. The metering devices are located at the entrance of flats.

Table 4.5 Length of the Cables within the Sample Building

	Flat 1	Flat 2
Floor 1	5 m	7 m
Floor 2	10 m	12 m
Floor 3	15 m	17 m
Floor 4	20 m	22 m
Floor 5	25 m	27 m

The losses are calculated and given in Appendix C. The annual losses are 22,086 kWh in the 20^{th} year. The total consumption is 3,506,632 kWh in the 20^{th} year. The ratio of losses is 0.63%.

4.3.2. Losses on the Cables between Distribution Boxes and Buildings

The locations of distribution boxes are the same in all design alternatives. Therefore, the losses on this section of the system are also is the same in all design alternatives. Total annual losses between distribution boxes and buildings for the sample residential area are calculated as 14,047 kWh in the 20^{th} year. In this case, the loss ratio is 0.4%. The detailed loss calculations are given in Appendix C.

4.3.3. Losses on the Cables Between Transformers and Distribution Boxes

The annual losses are calculated as 66,718 kWh in Design Alternative – 1, 72,827 kWh in Design Alternative – 2 and 66,747 kWh in Design Alternative – 3 in the 20^{th} year. The annual consumption of the sample residential area is 3,506,632 kWh in the 20^{th} year. The loss ratios are 1.9%, 2.1% and 1.9% of the total consumption. The detailed loss calculations are given in Appendix C.

The annual losses per consumer in Design Alternative – 1 are 71 kWh due to the cables between distribution boxes and transformers at the full load condition in the 20^{th} year. By assuming this value as an average, the total losses in Turkey can be calculated. So, the annual losses are nearly 1,639 million kWh. The share of the losses is 1.45% of TEDAS consumption.

4.4. Losses on Transformers

Technical data relating to losses of transformers used in this study are given in Table 4.6. The calculations of transformer daily load losses are given in Appendix C.

The ratio of the losses on transformers is 1.46%, 1.88% and 2.34% for Design Alternative – 1, 2 and 3 in the 20^{th} year. The share of no-load losses is too high in all three alternatives. Most of the losses on transformers are independent of current flowing on it. The share of no-load losses in transformer losses is 89%

in first year for Design Alternative – 1 and it is 67% in the 20th year. The losses on transformers have the biggest share in total system losses and no-load losses have biggest share in transformer losses.

Table 4.6 Loss Data of Distribution Transformers

Transformer Capacity (kVA)	1250 kVA	630 kVA	315 kVA
Voltage (kV)	34.5 / 0.4	34.5 / 0.4	34.5 / 0.4
No-Load Losses (W)	1,950	1,350	820
Load Losses (W)	14,000	8,000	5,150

By increasing the loading ratios of transformers, the required transformer capacity can be reduced. Therefore the total transformer no-load losses decrease with decreasing installed transformer capacity. Some transformers are required only peak load durations. Taking the transformers off when they are not required is also a good way of decreasing transformer no-load losses. For example, a shopping center can take off one of its two transformers during closed hours.

The number and capacity of the distribution voltage transformers in Turkish Electricity System in 2005 is given in Table 4.7. This information is gathered from Turkish Electricity Distribution Authority (TEDAS) publications. At the end of year 2005, the capacity of low voltage transformers is 78,184,915 kVA. The total no-load losses on LV transformers are 235 MW with the assumption of 0.3% no-load loss ratio. Then, the total amount of lost electrical energy is 2 billion kWh due to the transformer no-load losses.

Table 4.7 Capacity of Distribution Transformers in Turkey

Transformers		
Voltage Level	Number	Capacity (kVA)
33 / 0.4 kV	237,494	59,448,038
15.8 / 0.4 kV	30,386	8,541,474
10.5 / 0.4 kV	7,899	6,572,421
6.3 / 0.4 kV	8,182	3,622,982
Total	283,961	78,184,915

The Electric Power Research Institute (EPRI), which was established in 1973 as an independent, nonprofit center for public interest energy and environmental research, developed an amorphous steel core distribution transformer technology that reduces core losses by 60-70%. To decrease no-load losses of a transformer, the most effective way is using the conventional grain oriented magnetic steel core material with the amorphous magnetic steel core material. The losses would be approximately 65% lower. In the year 2005, if all conventional LV transformers in Turkey were replaced with the amorphous magnetic steel core transformers, the amount of saved energy could be 1.3 billion kWh. Therefore, a 209 MW natural gas power plant can be constructed with 209 million YTL.

4.5. Total Losses

The losses on the distribution transformers, the cables between transformers and distribution boxes, the cables between distribution boxes and buildings, the cables within the buildings and the meters are calculated to be able to find out the total losses. The total losses of each year are calculated in Appendix C. The annual losses in the 20th year are given in Table 4.8.

Table 4.8 Annual Losses in the 20th Year

Losses (kWh)		In 20th Year					
		Design Alt - 1		Design Alt - 2		Design Alt - 3	
Meters	voltage cct	8,234	87.05%	8,234	87.05%	8,234	87.05%
	current cct	1,225	12.95%	1,225	12.95%	1,225	12.95%
	total	9,460	100%	9,460	100%	9,460	100%
Cables	within building	22,086	21.47%	22,086	20.27%	22,086	21.47%
	between B&DB	14,047	13.66%	14,047	12.89%	14,047	13.65%
	between DB&TR	66,718	64.87%	72,827	66.84%	66,747	64.88%
	total	102,851	100%	108,960	100%	102,880	100%
TRs	no-load	34,164	66.94%	47,304	71.61%	57,466	69.98%
	load	16,875	33.06%	18,758	28.39%	24,649	30.02%
	total	51,039	100%	66,062	100%	82,114	100%
Total	meters	9,460	5.79%	9,460	5.13%	9,460	4.86%
	cables	102,851	62.96%	108,960	59.06%	102,880	52.91%
	TRs	51,039	31.25%	66,062	35.81%	82,114	42.23%
	total	163,350	100%	184,482	100%	194,454	100%
Total	no-load	42,398	25.96%	55,538	30.11%	65,700	33.79%
	load	120,952	74.04%	128,944	69.89%	128,754	66.21%
	total	163,350	100%	184,482	100%	194,454	100%
Consumption(kWh)		3,506,632		3,506,632		3,506,632	
Loss Ratio (%)		**4.66%**		**5.26%**		**5.55%**	
Cost of Losses (YTL)		26,345		29,753		31,362	
PV of Cost (YTL)		4,308		4,865		5,128	

The loss calculations show that the minimum losses occur in the Design Alternative – 1 with the ratio of 4.66% in the 20th year. The ratio of the load losses will increase in years because the system starts with the half load condition. When the system reaches full load condition, the current will be doubled. The load losses will increase with the square of the increase in current. The ratios of the current dependent losses will be 74% in the 20th year while it is 42% in the first year for Design Alternative – 1.

4.6. Comparison of Design Alternatives

The investment costs of design alternatives are calculated in Chapter 3. To be able to find out which alternative is more economic, the cost of the losses must be added to investment costs. The cost of losses is calculated and given in Appendix C. The cost of the losses is calculated for present values by using the interest rate of 10%. The comparison of three design alternatives according to total cost is given in Table 4.9.

Table 4.9 Comparison According to Total Cost

Costs	Design Alt - 1	Design Alt - 2	Design Alt - 3
Investment Cost (YTL)	454,968	623,228	955,297
Cost of Losses (YTL)	227,731	260,069	276,817
Total (YTL)	682,699	883,297	1,232,114
Investmen Cost Ratio	66.64%	70.56%	77.53%
Cost of Losses Ratio	33.36%	29.44%	22.47%

When the results of the cost calculations examined, it is obvious that Design Alternative – 1 is cheaper than others. Not only the cost of losses but also the investment cost is smaller in Design Alternative – 1. The investment cost is 2.0 times more than the cost of losses in Design Alternative – 1. It is 2.4 in Design

Alternative – 2 and 3.45 in Design Alternative – 3. Therefore the cost of losses can not be neglected when deciding which design is more economic.

4.7. Losses on Medium Voltage Distribution Systems

The system between the high voltage network and the low voltage distribution systems can be designed with one voltage level (154 kV / 34.5 kV / 0.4 kV) or two voltage levels (154 kV / 34.5 kV / 10.5 kV (or 6.3 kV) / 0.4 kV). In both cases, the system is designed as loop but operated as radial in Turkey. Therefore, the medium voltage cables are loaded 50% in normal operating conditions and up to 100% in emergency situations. The losses with both design alternatives are calculated. The results are given in Table 4.10. The losses are smaller with one voltage level. Unfortunately, the common application in Turkey was based on two voltage levels.

Table 4.10 Losses on Medium Voltage Distribution Systems

34.5 / 0.4 kV	Loss Ratio (%)	34.5 / 10.5 / 0.4 kV	Loss Ratio (%)
Design Alternative - 1	0.18%	Design Alternative - 1	1.37%
Design Alternative - 2	0.16%	Design Alternative - 2	1.31%
Design Alternative - 3	0.16%	Design Alternative - 3	1.29%

4.8. Effects of Operating Parameters on Losses

The I^2R losses can be decreased by decreasing resistance or current. The raw material can be changed to decrease the resistance. There are only two raw materials which are economically and technically available, copper and aluminum. It is possible to carry more current with fewer losses by using copper wires. The cross-section of cables can also be decreased to decrease losses. The shape of the daily load curve can be modified to decrease current. Increasing the power factor is also one of the ways of decreasing current. Voltage drops has effect on flowing current because most of the consumption is based on the constant power loads. Unbalanced loads are also bad effect on losses.

4.8.1. The Effect of Power Factor

The power factor of residential consumers in Turkey is around 0.9. If the individual compensation is applied to the equipments in houses, it is possible to obtain almost unity power factor. In this case, the current drawn by a residential consumer decreases and the losses also decrease. All loss calculations are repeated with unity power factor and the results are shown in Table 4.11.

By improving power factor from 0.9 to unity, 14.07% decrease in losses is obtained in Design Alternative – 1. The manufacturers of washing machines, refrigerators, dishwashers and lighting equipments can be promoted or forced by regulation to apply individual compensation to their products.

Table 4.11 Annual Losses with Power Factor of 1.0

Losses (kWh)		In 20th Year					
		Design Alt - 1		Design Alt - 2		Design Alt - 3	
Total	meters	9,227	6.57%	9,227	5.77%	9,227	5.43%
	cables	83,309	59.35%	88,258	55.17%	83,333	49.02%
	TRs	47,833	34.08%	62,498	39.07%	77,431	45.55%
	total	140,369	100%	159,983	100%	169,991	100%
Total	no-load	42,398	30.20%	55,538	34.72%	65,700	38.65%
	load	97,971	69.80%	104,444	65.28%	104,291	61.35%
	total	140,369	100%	159,983	100%	169,991	100%
Consumption(kWh)		3,506,632		3,506,632		3,506,632	
Loss Ratio (%)		**4.00%**		**4.56%**		**4.85%**	
Base Case Loss Ratio (%)		*4.66%*		*5.26%*		*5.55%*	
Change in Losses (%)		***-14.07%***		***-13.28%***		***-12.58%***	

4.8.2. The Effect of Shape of Daily Load Curve

The I^2R losses are directly related with the current and so the consumption habits of consumers. Decreasing the consumption is not a correct way to decrease the losses because the purpose of the electricity system is to provide required electrical energy to the consumers. However, decreasing the peaks of load curve without changing the consumption decreases the I^2R losses.

A typical daily load curve is calculated in Chapter 2 and the loss calculations in Chapter 4 are based on this curve. The peak load is 2,250 W. The required power above 1,000 W is distributed to other time intervals without changing the consumption. The loss calculations are repeated and the summary is given in Table 4.12.

Table 4.12 Losses with Modified Daily Load Curve

Losses (kWh)		In 20th Year					
		Design Alt - 1		Design Alt - 2		Design Alt - 3	
Total	meters	9,179	5.91%	9,179	5.21%	9,179	4.93%
	cables	95,387	61.42%	101,282	57.49%	95,191	51.17%
	TRs	50,729	32.67%	65,717	37.30%	81,661	43.90%
	total	155,295	100%	176,178	100%	186,032	100%
Total	no-load	42,398	27.30%	55,538	31.52%	65,700	35.32%
	load	112,897	72.70%	120,639	68.48%	120,332	64.68%
	total	155,295	100%	176,178	100%	186,032	100%
Consumption(kWh)		3,506,632		3,506,632		3,506,632	
Loss Ratio (%)		**4.43%**		**5.02%**		**5.31%**	
Base Case Loss Ratio (%)		*4.66%*		*5.26%*		*5.55%*	
Change in Losses (%)		***-4.93%***		***-4.50%***		***-4.33%***	

Shifting the consumption from the peak time intervals to other time intervals provides considerable decrease in the total losses. In Design Alternative – 1, 4.93% of improvement is achieved. Shifting the consumption can be achieved by offering different tariffs to the consumers.

An increase in the losses is expected when the duration of peak demand is made longer without changing the daily consumption. The peak demand is 2,250 W along 15 minutes in the typical daily load curve. The duration of peak demand is lengthened to 30 minutes, 45 minutes and 60 minutes. The related calculations are and the results summary is given in Table 4.13. The variations of the loss ratio with the peak demand durations are given in Figure 4.1 for three design alternatives.

Table 4.13 Loss Ratios with Longer Peak Durations

Peak Duration (minutes)	Design Alt - 1	Design Alt - 2	Design Alt - 3
15	4.66%	5.26%	5.55%
30	4.77%	5.37%	5.66%
45	5.05%	5.66%	5.95%

When the duration of peak demand is increased to 60 minutes, the increase in losses is 19.37%, 17.92% and 16.96% for Design Alternative – 1, 2 and 3.

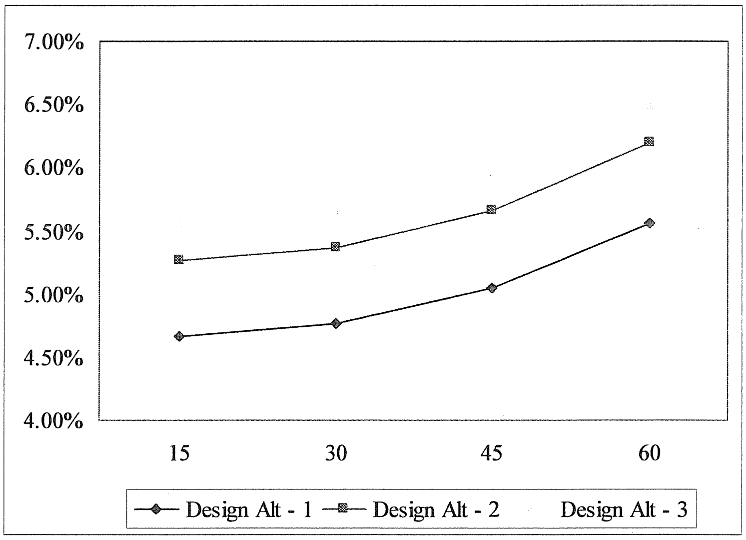


Figure 4.1 Loss Ratio with Longer Peak Durations

4.8.3. The Effect of Voltage Drop

When the consumption of a residential area increases above the transformer rated capacity, the transformer and the lines keeps feed the residential area up to thermal limits. Unfortunately the voltage drop occurs due to the overloading of the transformer and the lines. Voltage drops in consumer voltages cause increase in the current drawn by consumers because most of the loads in houses are constant power. In the case of decrease in voltage, increase in current occurs to provide required power to load.

A new design is made by using the same topology with Design Alternative – 1 but overhead lines are used instead of cables and 500 kVA transformers are used instead of 1,250 kVA transformers. The losses on the overhead lines are calculated by using the maximum voltage drops of the overhead lines. The maximum voltage drop is 5.0% and transformer loading is 94% in this scenario, called as Situation – 1. The summary of the results are given in Table 4.14.

After that, the typical daily load curve is multiplied by 2 to simulate overloading situation. It is assumed that the transformers and overhead lines can withstand overloading. Voltage drop and loss calculations are repeated. The maximum voltage drop is 10.0% and transformer loading is 188% in this scenario, called as Situation – 2. The summary of the results are given in Table 4.14.

Finally, the 500 kVA transformers are replaced by 1,000 kVA transformers without changing the overhead lines. It is assumed that the secondary side voltages of distribution transformers are always 0.4 kV. Voltage drop and loss calculations are repeated. The maximum voltage drop is 10.0% and transformer loading is 94% in this scenario, called as Situation – 3. The summary of the results are given in Table 4.14.

Table 4.14 Effects of Voltage Drop on Losses

		Situation 1	Situation 2	Situation 3
Max. Demand of a Consumer (VA)		2,500	5,000	5,000
Diversified Demand of the District (kVA)		940	1,880	1,880
Transformers (kVA)		500	500	1,000
Transformer Capacity (kVA)		1,000	1,000	2,000
Transformer Loading (%)		94%	188%	94%
Maximum Voltage Drop (%)		5.00%	10.00%	10.00%
Daily Total Consumption (Wh)		4,806,925	9,613,850	9,613,850
Between TR and DB	Losses (Wh)	105,686	439,959	439,959
	Ratio (%)	2.20%	4.58%	4.58%
Transformer No-Load	Losses (Wh)	60,000	60,000	76,800
	Ratio (%)	1.25%	0.62%	0.80%
Transformer Load	Losses (Wh)	34,879	139,514	63,040
	Ratio (%)	0.73%	1.45%	0.66%
Total	Losses (Wh)	200,565	639,473	579,799
	Ratio (%)	4.17%	6.65%	6.03%

While the losses on the lines are 2.2% in Situation – 1, they are 4.58% in Situation – 2. The loss ratio is 2.08 times greater as a result of overloading and voltage drop. When the system is overloaded for a short time interval, the losses on the lines in this time interval are doubled. In addition to that, the transformer load losses are also doubled. In Situation – 3, the amount of losses on the lines is the same but there is great decrease in transformer load losses because when the transformers are replaced with higher capacity transformers, the overloading problem of the transformers is solved and the load losses of the transformers are decreased. Unfortunately, the overloading problem of the overhead lines still exists. For this reason, the losses on the lines are the same in Situation – 2 and 3.

4.8.4. The Effect of Unbalanced Loads

Three phases are never equally loaded in real life because there are lots of electrical equipments in the houses and all of them are single phase devices. To be able to load three phases equally, it is necessary to run all single phase electrical devices in synchronization. It is not possible due to the different needs of consumers. Therefore, the LV distribution systems are inevitably loaded unequally in phases.

When the phases are loaded unequally, the current is divided unequally between phases. In this case, the losses change with the different phase loading conditions. Moreover, the sum of phase currents is not equal to zero. There is current on neutral wire and so, there are losses on the neutral wire. The sample case, shown in Figure 4.2, is used to illustrate the effect of phase loading on losses.

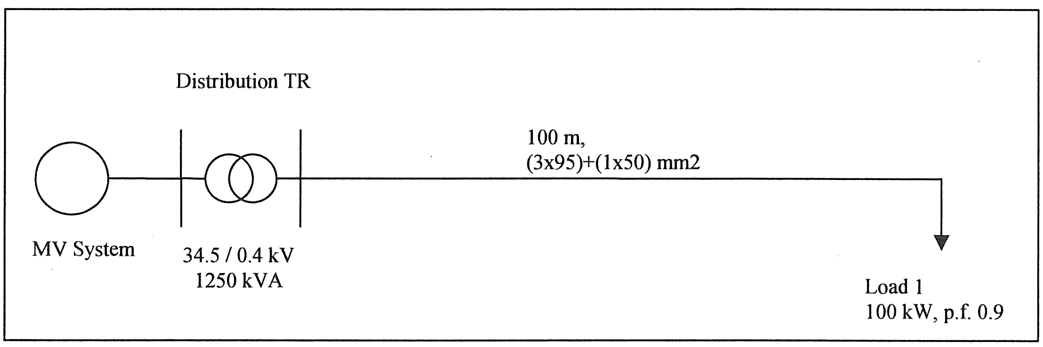


Figure 4.2 Sample Case for Unequal Phase Loading

Firstly, the losses are calculated assuming that the phases are equally loaded. And secondly, the losses are calculated with 70%, 20% and 10% phase loadings. In addition, the losses are calculated with 25%, 30% and 45% phase loadings. The calculations are shown in Table 4.15. When the phases are equally loaded, the losses are 1,650 W. The losses become 5,742 W with the loading ratios of 70%, 20% and 10%. Although the same amount of power is supplied to the customers, the losses are 2.5 times more. The losses become 2,079 W with the loading ratios of 25%, 30% and 45%. With a very small unbalance in phase loading, there is 26% increase in losses due to the unequal phase loading.

Table 4.15 Losses with Unequally Loaded Phases

Phase Loading	Phases	Load					Cable	Losses
		P (kW)	%	p.f.	V (volts)	I (A)	R (ohm)	(W)
Equally	3-phases	100	100%	0.9	380	169	0.0193	1,650
Unequally	Phase 1	70	70%	0.9	219	355	0.0193	2,426
	Phase 2	20	20%	0.9	219	101	0.0193	198
	Phase 3	10	10%	0.9	219	51	0.0193	50
	Notr	-				282	0.0386	3,069
	Total	100	100%	-	-	506	-	5,742
Unequally	Phase 1	25.0	25%	0.9	219	127	0.0193	309
	Phase 2	30.0	30%	0.9	219	152	0.0193	446
	Phase 3	45.0	45%	0.9	219	228	0.0193	1,002
	Notr	-				91	0.0386	322
	Total	100.0	100%	-	-	506	-	2,079

CHAPTER 5

CONCLUSION

The main topic of this study is the distribution system losses of residential consumers. The residential area between Middle East Technical University and Cankaya University is chosen for designing its distribution system and to evaluate the losses through this system. 2x1250 kVA, 4x630 kVA and 8x315 kVA transformer alternatives are used in designs to provide the required transformer capacity. When the first investment costs of three design alternatives are compared, Design Alternative – 1 is much cheaper and Design Alternative – 3 is too expensive although the length of cables used in three design alternatives are very close to each other. The reason is that the cost of the transformers has the biggest share in the total cost. In conclusion, the Design Alternative – 1 is the most economic one regarding the first investment cost.

The distribution system losses are evaluated through these three designed systems by using the calculated typical daily load curve to realize the effects of system design. The loss calculations show that the minimum losses occur in the Design Alternative – 1 with the ratio of 4.66% in the 20th year. The ratio of the load losses will increase in years because the system starts with the half load condition. When the system reaches full load condition, the current will be doubled. The load losses will increase with the square of the increase in current. The ratios of the current dependent losses will be 74% in the 20th year while it is 42% in the first year for Design Alternative – 1. Therefore, the low voltage distribution system losses are smaller in Design Alternative – 1.

When the results of the total owning cost are examined, it is obvious that Design Alternative – 1 is cheaper than the others. Not only the cost of losses but also the investment cost is smaller in Design Alternative – 1. Therefore, the Design Alternative – 1 is chosen for the application according to total owning cost which is the sum of the first investment cost and the cost of losses. Its first investment cost is nearly 455 million YTL and its total owning cost is 683 million YTL with the loss ratio of 4.66% considering the 30 years economic life time.

In conclusion, the designs with less number of transformers have advantages in the first investment cost and the loss ratios. The first investment cost is lower because the transformers have the biggest share in total and buying a transformer capacity as one transformer is cheaper than buying it as two transformers. The loss ratio is less because the main source of low voltage distribution systems is transformers because of the constant no-load losses.

Some important points related with losses can be summarized as follows:

- The losses on electronic meters can be decreased up to half of it by utilizing effective design and proper circuit elements.

- Metering devices were installed previously on the entrance of the flats instead of the entrance of the building. Nowadays, the metering devices are moved from the entrance of flats to the entrance of building by the regulation. As a result, the power losses due to the resistance of cables within the building are charged to the consumers. Therefore, the cost of the power losses will be paid by the source of the losses.

- The main solution for decreasing no-load losses of a transformer is using the amorphous magnetic steel as core material instead of conventional grain oriented magnetic steel. The test applications resulted in up to 65% decrease in no-load losses. The price of the amorphous magnetic steel core transformers is not available in the market. A calculation was performed to determine whether the cost of such a transformer would be more economic or not, regarding the no-load losses incurred during an economic lifetime of 30 years. The result is that the cost of an amorphous magnetic steel core transformer would be approximately 1.5 times higher than a conventional one.

- There are two types of application regarding the voltage level of medium voltage systems. First one is using only one voltage level, i.e. 34.5 kV. The other one is using two combined voltage levels, i.e. 34.5 kV / (15.0 - 6.3) kV. The losses are smaller with one voltage level. Unfortunately, the common application in Turkey was based on two voltage levels.

- By improving power factor from 0.9 to unity, a decrease between 12.58% and 14.07% in losses is achieved.

- Extending the peak demand duration causes increase in losses between 16.96% - 19.37%.

- The loss ratio is approximately two times greater as a result of overloading and voltage drop.

- Very small unbalanced loading of phases causes up to 26% increase in loss ratio. When the greater unbalances are considered, it reaches to a rate of 250% of balanced conditions.

The calculated loss ratio is the ratio of an ideal system with no voltage drop, no overloading, balanced phase loadings, and copper cables instead of aluminum lines. Moreover, the losses on the contact points of equipments and the protection elements are not included in the calculations. Furthermore, the instantaneous needle peaks of load curve are averaged by using a load curve based on 15 minutes time intervals. In addition, the systems have been designed properly regarding the future increases in the demand. The effect of these excluded factors must also be considered to be able to compare the calculated loss ratio with the loss ratio in real life.

Low voltage system loss ratio is changing between 4.66% and 5.55% according to the calculations. Loss ratio is between 0.16% and 1.37% in medium voltage distribution system. As a result, the loss ratio of a distribution system can be assumed as 6% in accordance with the calculations. Some of the operating parameters, i.e. power factor, shape of load curve, cause an increase in total losses up to 20%. Moreover, some of them, i.e. voltage drop, overloading, phase unbalance, result in increases up to two times in cable losses and it give rise to 33% increase in total losses. Therefore, the loss ratio of a distribution system can be assumed as 8.0% in Turkey.

The average loss ratio is around 7.5% in OECD Countries and it is 6% in some of them. Unfortunately, it was published to be 17.8% in Turkey for the year 2005, whereas it was 25% only three years ago. These published values include the technical losses and the theft. According to calculations, the technical losses can be taken around 8% in Turkey. The rest of the losses are theft, hidden subsidies, unbilled and uncollected ones. The difference between published and calculated loss ratios is around 10%. In the year 2005, the amount of the lost money was 1.2 billion YTL which is sufficient to construct a 1,200 MW natural gas power plant in each year. 1,200 MW was equal to the 3.05% of the installed generation capacity. The growth ratio of the installed capacity was 7.06% and the growth ratio of peak demand was 5.92% between 1996 and 2005. In conclusion, the almost half of the required new capacity addition can be provided by preventing the theft and stopping the hidden subsidies.

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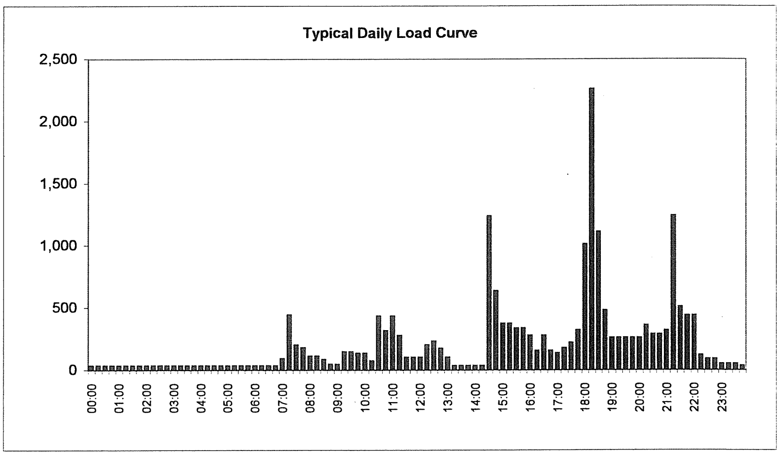
APPENDIX A: LOAD CALCULATIONS

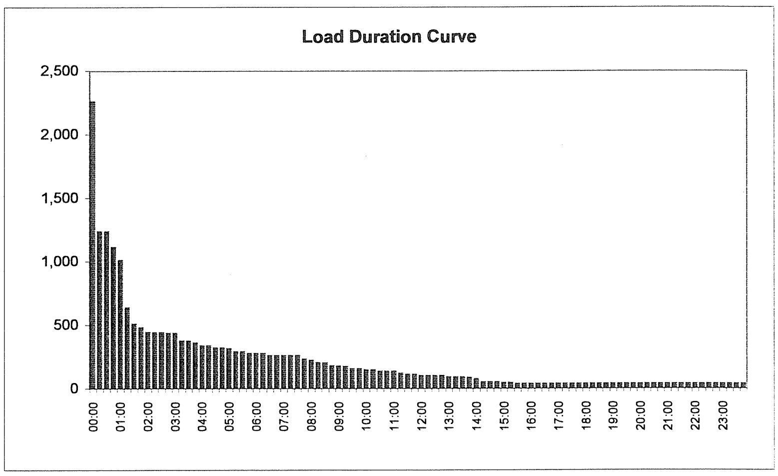
THE TYPICAL DAILY LOAD CURVE FOR A RESIDENTIAL CONSUMER

Hour		Electrical Power (W)													Consumption (Wh)	Load Curve (W)	Load Duration Curve (W)
from	to	Refrigerator	Oven	Dishwasher	Kitchen Devices	Washing Mach.	Hair Dryer	Water Heater	Iron	TV	Audio System	Computer	Elec. Broom	Lighting			
00:00	00:15	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	2,250
00:15	00:30	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	1,231
00:30	00:45	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	1,229
00:45	01:00	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	1,103
01:00	01:15	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	1,003
01:15	01:30	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	629
01:30	01:45	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	501
01:45	02:00	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	473
02:00	02:15	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	436
02:15	02:30	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	432
02:30	02:45	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	432
02:45	03:00	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	427
03:00	03:15	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	427
03:15	03:30	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	367
03:30	03:45	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	367
03:45	04:00	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	352
04:00	04:15	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	329
04:15	04:30	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	329
04:30	04:45	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	313
04:45	05:00	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	311
05:00	05:15	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	307
05:15	05:30	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	281
05:30	05:45	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	281
05:45	06:00	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	269
06:00	06:15	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	269
06:15	06:30	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	269
06:30	06:45	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	252
06:45	07:00	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	252
07:00	07:15	50	0	0	0	0	0	10	0	2	1	1	0	20	21	84	252
07:15	07:30	50	72	0	30	0	60	200	0	2	1	1	0	20	109	436	252
07:30	07:45	50	72	0	0	0	0	10	0	40	1	1	0	20	49	194	252
07:45	08:00	50	0	0	30	0	0	40	0	40	1	1	0	10	43	172	224
08:00	08:15	50	0	0	0	0	0	40	0	2	1	1	0	10	26	104	213
08:15	08:30	50	0	0	0	0	0	40	0	2	1	1	0	10	26	104	196
08:30	08:45	50	0	0	0	0	0	10	0	2	10	1	0	5	20	78	194
08:45	09:00	10	0	0	0	0	0	10	0	2	10	1	0	5	10	38	172
09:00	09:15	10	0	0	0	0	0	10	0	2	10	1	0	5	10	38	169
09:15	09:30	10	0	0	0	0	0	10	0	2	10	1	100	5	35	138	166
09:30	09:45	10	0	0	0	0	0	10	0	2	10	1	100	5	35	138	149
09:45	10:00	10	0	0	0	0	0	10	0	2	1	1	100	5	32	129	149
10:00	10:15	10	0	0	0	0	0	10	0	2	1	1	100	5	32	129	138
10:15	10:30	10	0	0	0	0	0	10	0	40	1	1	0	5	17	67	138
10:30	10:45	10	0	0	0	0	0	10	360	40	1	1	0	5	107	427	129
10:45	11:00	10	0	0	0	0	0	10	240	40	1	1	0	5	77	307	129
11:00	11:15	10	0	0	0	0	0	10	360	40	1	1	0	5	107	427	129
11:15	11:30	10	0	0	0	0	0	10	240	2	1	1	0	5	67	269	112
11:30	11:45	75	0	0	0	0	0	10	0	2	1	1	0	5	24	94	104
11:45	12:00	75	0	0	0	0	0	10	0	2	1	1	0	5	24	94	104
12:00	12:15	75	0	0	0	0	0	10	0	2	1	1	0	5	24	94	94
12:15	12:30	75	72	0	0	0	0	40	0	2	1	1	0	5	49	196	94
12:30	12:45	75	0	0	100	0	0	40	0	2	1	1	0	5	56	224	94
12:45	13:00	75	72	0	0	0	0	10	0	2	1	1	0	5	42	166	94
13:00	13:15	75	0	0	0	0	0	10	0	2	1	1	0	5	24	94	84
13:15	13:30	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	82
13:30	13:45	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	82
13:45	14:00	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	78
14:00	14:15	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	67
14:15	14:30	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	44
14:30	14:45	10	0	0	0	1200	0	10	0	2	1	1	0	5	307	1,229	44
14:45	15:00	10	0	0	0	600	0	10	0	2	1	1	0	5	157	629	44
15:00	15:15	10	0	0	0	300	0	10	0	40	1	1	0	5	92	367	38
15:15	15:30	10	0	0	0	300	0	10	0	40	1	1	0	5	92	367	38
15:30	15:45	10	0	0	0	300	0	10	0	2	1	1	0	5	82	329	29
15:45	16:00	10	0	0	0	300	0	10	0	2	1	1	0	5	82	329	29
16:00	16:15	10	0	0	0	0	0	10	240	2	1	1	0	5	67	269	29
16:15	16:30	10	0	0	0	0	0	10	120	2	1	1	0	5	37	149	29
16:30	16:45	10	0	0	0	0	0	10	240	2	1	1	0	5	67	269	29
16:45	17:00	10	0	0	0	0	0	10	120	2	1	1	0	5	37	149	29
17:00	17:15	10	0	0	0	0	0	10	0	2	1	1	100	5	32	129	29
17:15	17:30	50	0	0	0	0	0	10	0	2	1	1	100	5	42	169	29
17:30	17:45	50	0	0	100	0	0	40	0	2	10	1	0	10	53	213	29
17:45	18:00	150	0	0	100	0	0	40	0	2	10	1	0	10	78	313	29
18:00	18:15	150	600	0	150	0	0	40	0	2	10	1	0	50	251	1,003	29
18:15	18:30	150	1440	0	400	0	0	47	0	2	10	1	0	200	563	2,250	29
18:30	18:45	150	600	0	150	0	0	40	0	2	10	1	0	150	276	1,103	29
18:45	19:00	50	120	0	100	0	0	40	0	2	10	1	0	150	118	473	29
19:00	19:15	50	0	0	0	0	0	10	0	40	1	1	0	150	63	252	29
19:15	19:30	50	0	0	0	0	0	10	0	40	1	1	0	150	63	252	29
19:30	19:45	50	0	0	0	0	0	10	0	40	1	1	0	150	63	252	29
19:45	20:00	50	0	0	0	0	0	10	0	40	1	1	0	150	63	252	29
20:00	20:15	50	0	0	0	0	0	10	0	40	1	1	0	150	63	252	29
20:15	20:30	50	0	0	0	0	0	10	0	40	1	1	100	150	88	352	29

THE TYPICAL DAILY LOAD CURVE FOR A RESIDENTIAL CONSUMER

Hour		Electrical Power (W)													Consumption (Wh)	Load Curve (W)	Load Duration Curve (W)
from	to	Refrigerator	Oven	Dishwasher	Kitchen Devices	Washing Mach.	Hair Dryer	Water Heater	Iron	TV	Audio System	Computer	Elec. Broom	Lighting			
20:30	20:45	50	0	0	0	0	0	10	0	40	1	30	0	150	70	281	29
20:45	21:00	10	0	0	0	0	0	10	0	80	1	30	0	150	70	281	29
21:00	21:15	10	0	0	0	0	0	40	0	80	1	30	0	150	78	311	29
21:15	21:30	10	0	960	0	0	60	40	0	80	1	30	0	50	308	1,231	29
21:30	21:45	10	0	320	0	0	0	10	0	80	1	30	0	50	125	501	29
21:45	22:00	10	0	320	0	0	0	10	0	40	1	1	0	50	108	432	29
22:00	22:15	10	0	320	0	0	0	10	0	40	1	1	0	50	108	432	29
22:15	22:30	10	0	0	0	0	0	10	0	40	1	1	0	50	28	112	29
22:30	22:45	10	0	0	0	0	0	10	0	40	1	1	0	20	21	82	29
22:45	23:00	10	0	0	0	0	0	10	0	40	1	1	0	20	21	82	29
23:00	23:15	10	0	0	0	0	0	10	0	2	1	1	0	20	11	44	29
23:15	23:30	10	0	0	0	0	0	10	0	2	1	1	0	20	11	44	29
23:30	23:45	10	0	0	0	0	0	10	0	2	1	1	0	20	11	44	29
23:45	00:00	10	0	0	0	0	0	10	0	2	1	1	0	5	7	29	29
	Total	663.75	762	480	290	750	30	386.75	480	316	48.75	60.25	175	671.3	5,114	-	-
Ratios (%):		12.98	14.90	9.39	5.67	14.67	0.59	7.56	9.39	6.18	0.95	1.18	3.42	13.13	100.00		
		Daily Consumption (Wh): 5,114					***Monthly Consumption (kWh): 153.41***						***Daily Peak Load (W): 2,250***				



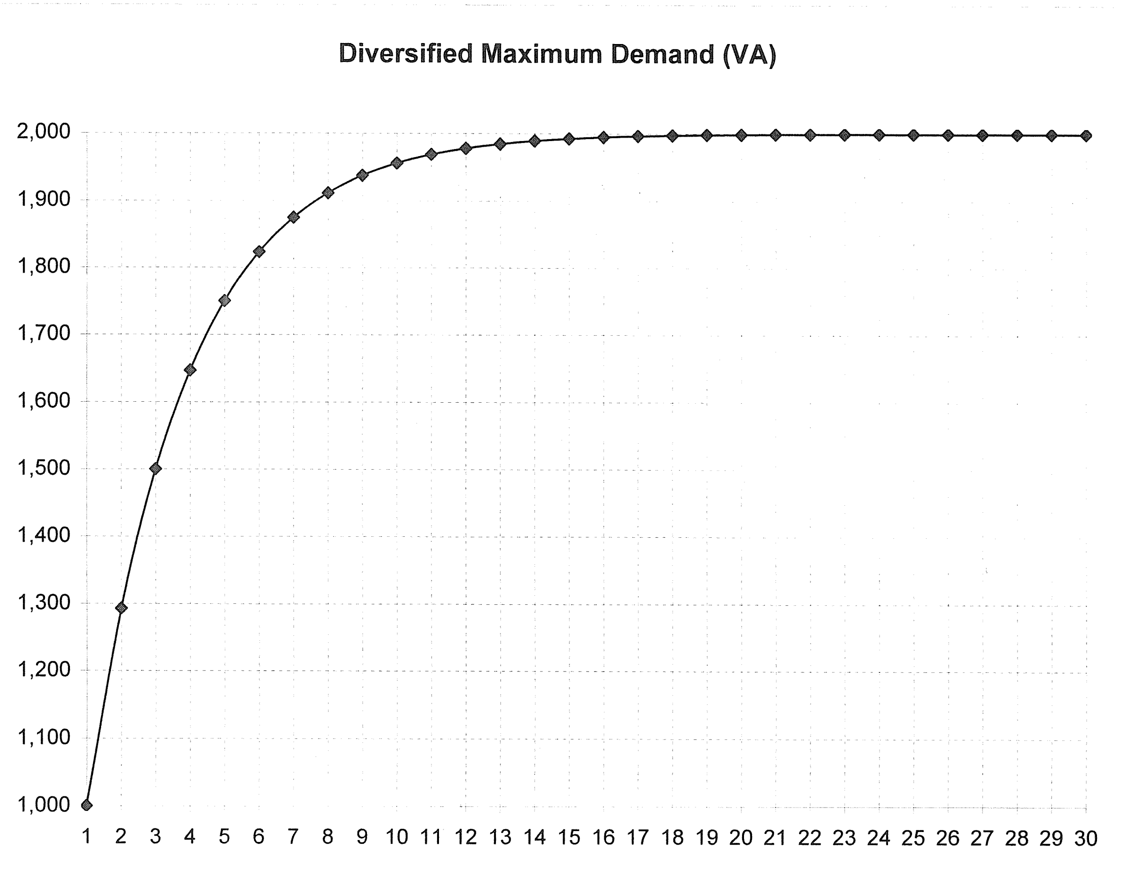


DIVERSIFIED MAXIMUM DEMAND IN YEARS

Year	Diversified Max. Demand (VA)	Increase Ratio (%)
1	1,000.00	0.00%
2	1,292.89	29.29%
3	1,500.00	16.02%
4	1,646.45	9.76%
5	1,750.00	6.29%
6	1,823.22	4.18%
7	1,875.00	2.84%
8	1,911.61	1.95%
9	1,937.50	1.35%
10	1,955.81	0.94%
11	1,968.75	0.66%
12	1,977.90	0.46%
13	1,984.37	0.33%
14	1,988.95	0.23%
15	1,992.19	0.16%
16	1,994.48	0.11%
17	1,996.09	0.08%
18	1,997.24	0.06%
19	1,998.05	0.04%
20	1,998.62	0.03%
21	1,999.02	0.02%
22	1,999.31	0.01%
23	1,999.51	0.01%
24	1,999.65	0.01%
25	1,999.76	0.01%
26	1,999.83	0.00%
27	1,999.88	0.00%
28	1,999.91	0.00%
29	1,999.94	0.00%
30	1,999.96	0.00%

a= 0.34657359

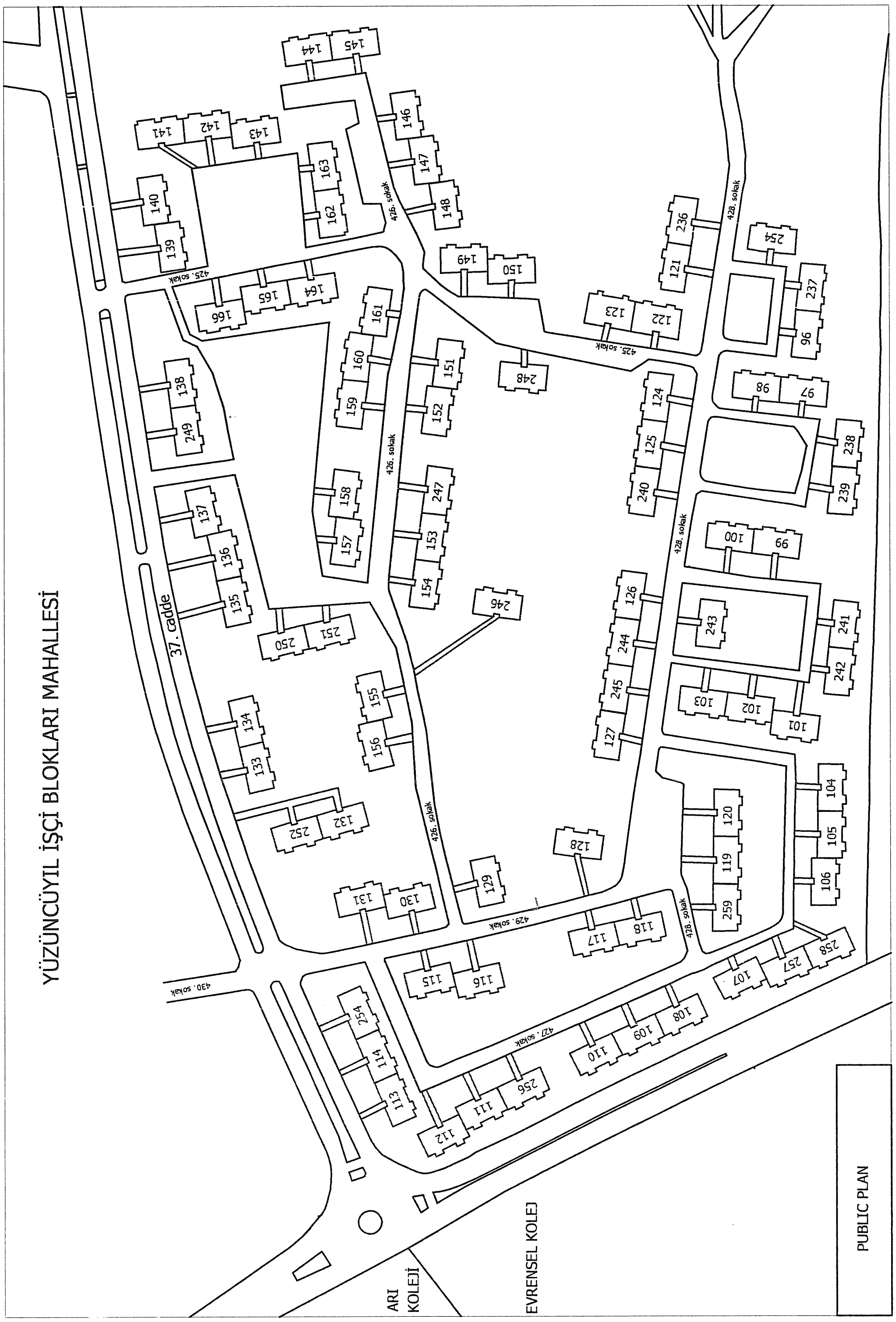
$S(t)= 2{,}000 \times (1-e^{-a(t+1)})$



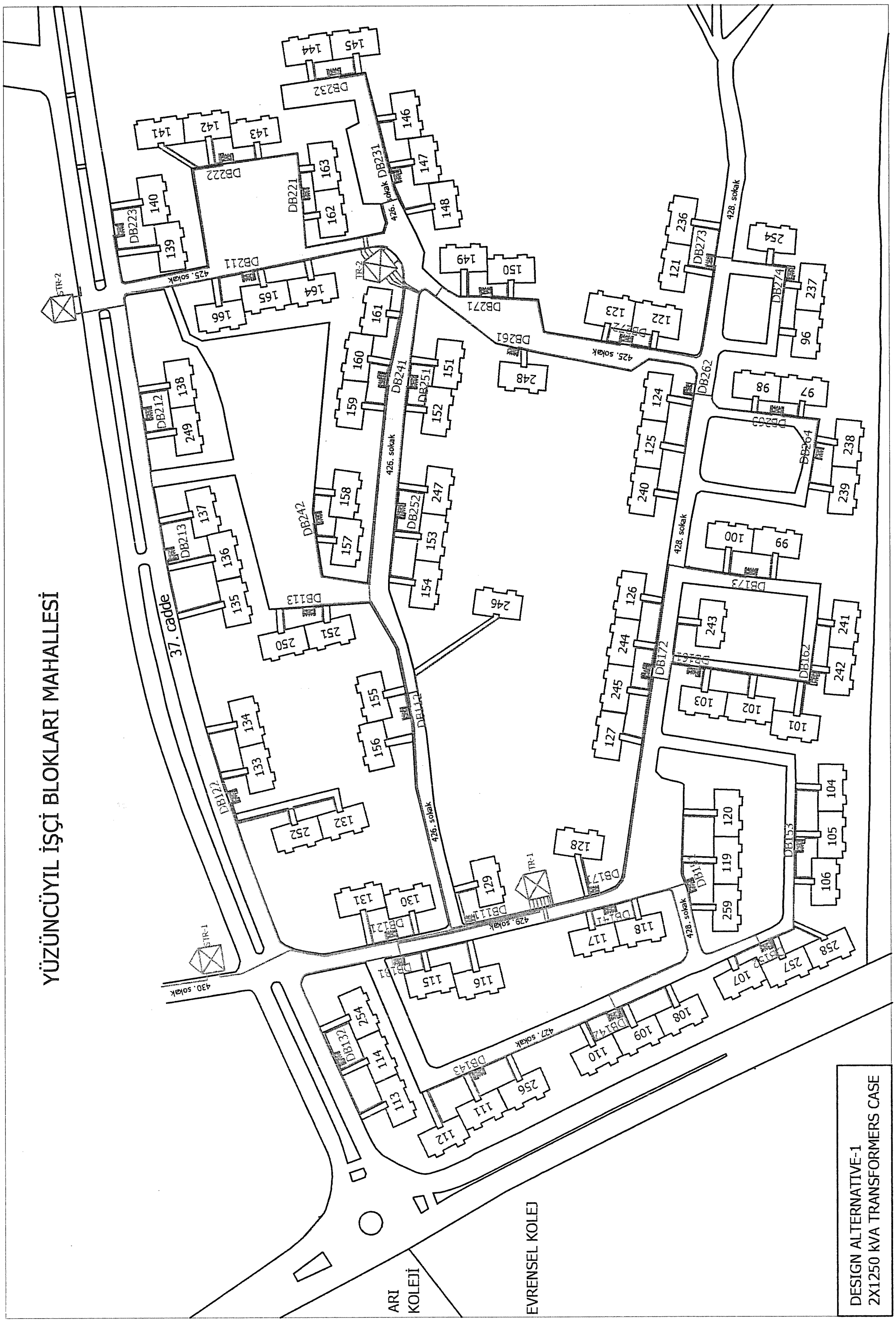
APPANDIX B: DESIGN CALCULATIONS

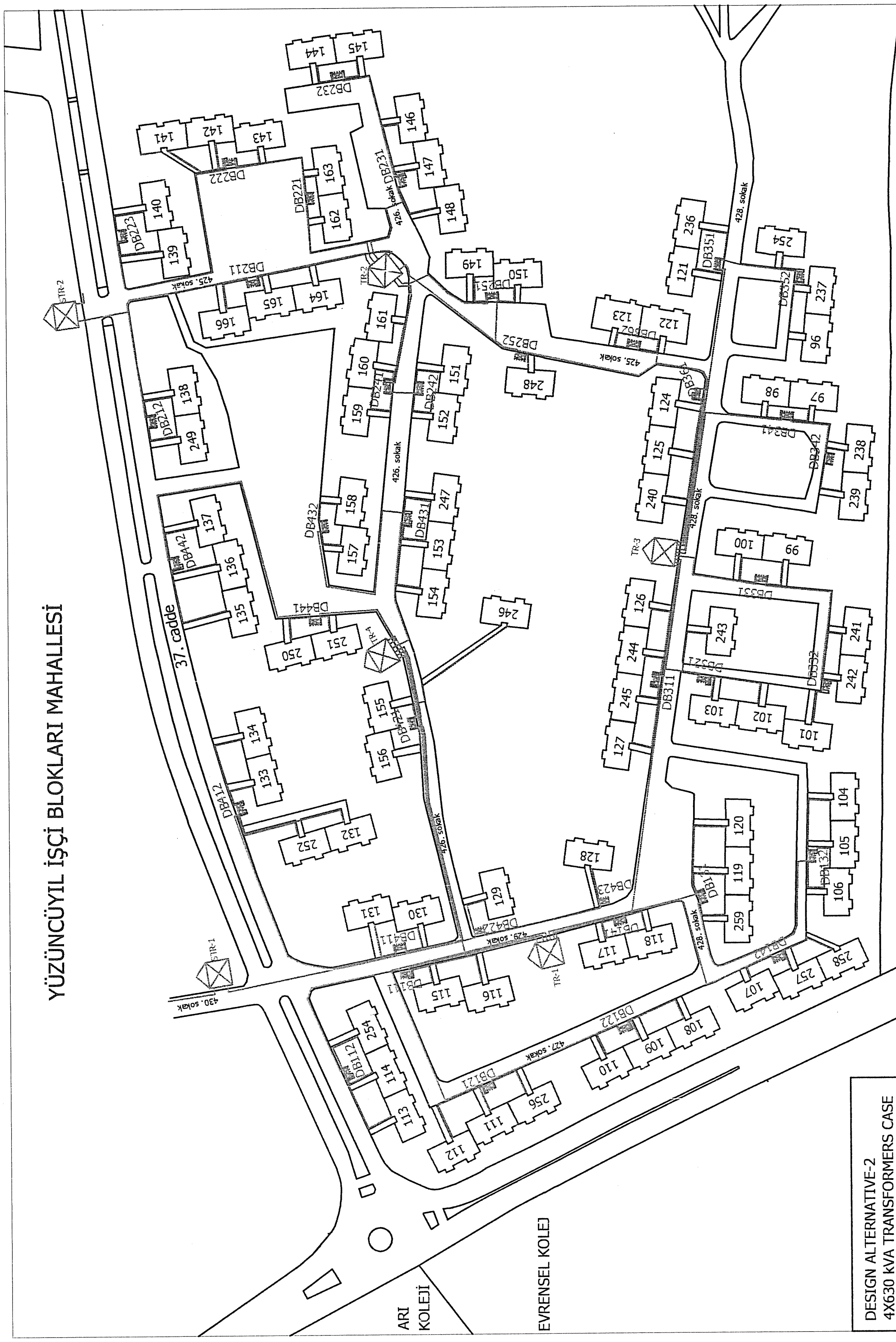
FIRST INVESTMENT COSTS

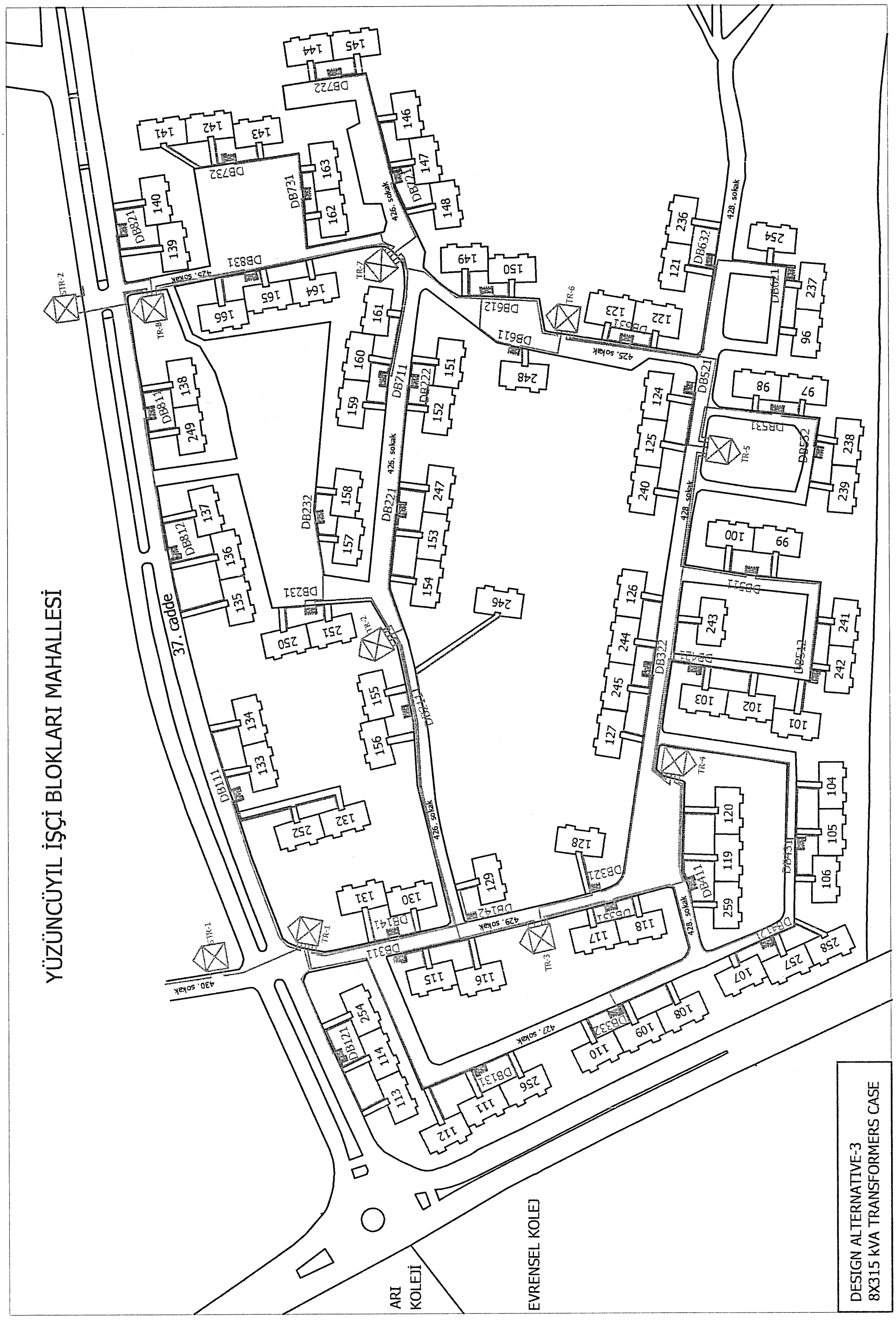
Name of Equipment		Unit Cost (unit/YTL)		Design Alt - 1		Design Alt - 2		Design Alt - 3	
				Unit	Cost	Unit	Cost	Unit	Cost
34.5/0.4 kV 1250 kVA transformer	Building Structure	34,910.21	108,987.70	2.00	217,975.40	0.00	0.00	0.00	0.00
	Transformer	25,367.18							
	Incoming Feeder Cell	5,879.33							
	Measuring Cell	12,078.00							
	Outgoing Feder Cell	25,897.66							
	LV panel	4,855.32							
34.5/0.4 kV 630 kVA transformer	Building Structure	34,910.21	99,019.64	0.00	0.00	4.00	396,078.56	0.00	0.00
	Transformer	16,279.43							
	Incoming Feeder Cell	5,879.33							
	Measuring Cell	12,078.00							
	Outgoing Feder Cell	25,897.66							
	LV panel	3,975.01							
34.5/0.4 kV 315 kVA transformer	Building Structure	34,910.21	91,914.13	0.00	0.00	0.00	0.00	8.00	735,313.04
	Transformer	10,689.53							
	Incoming Feeder Cell	5,879.33							
	Measuring Cell	12,078.00							
	Outgoing Feder Cell	25,897.66							
	LV panel	2,459.40							
34.5 kV Cable – (3x95) mm^2		88.72		590.30	52,372.60	758.00	67,251.28	969.00	85,971.62
Distribution Boxes		1,004.35		38.00	38,165.30	38.00	38,165.30	38.00	38,165.30
0.4 kV Cable – ((3x95)+(1x50)) mm^2		47.24		1,288.24	60,853.88	212.60	10,042.80	0.00	0.00
0.4 kV Cable – ((3x70)+(1x35)) mm^2		38.92		391.82	15,248.46	404.75	15,751.66	0.00	0.00
0.4 kV Cable – ((3x50)+(1x25)) mm^2		32.52		349.24	11,355.89	483.25	15,713.36	0.00	0.00
0.4 kV Cable – ((3x35)+(1x16)) mm^2		28.16		492.22	13,859.93	572.63	16,124.12	732.70	20,631.37
0.4 kV Cable – ((3x25)+(1x16)) mm^2		25.54		111.13	2,838.15	617.67	15,774.67	623.23	15,916.67
0.4 kV Cable – ((3x16)+(1x10)) mm^2		22.31		0.00	0.00	270.18	6,027.99	761.98	17,000.54
0.4 kV Cable – (4x10) mm2		20.51		2,062.12	42,298.21	2,062.12	42,298.21	2,062.12	42,298.21
The Cost of Transformers				217,975.40	47.91%	396,078.56	63.55%	735,313.04	76.97%
The Cost of Distribution Boxes				38,165.30	8.39%	38,165.30	6.12%	38,165.30	4.00%
The Cost of MV Cables				52,372.60	11.51%	67,251.28	10.79%	85,971.62	9.00%
The Cost of LV Cables				146,454.51	32.19%	121,732.79	19.53%	95,846.78	10.03%
Total				***454,967.81***		***623,227.93***		***955,296.74***	



YÜZÜNCÜYIL İŞÇİ BLOKLARI MAHALLESİ
37. cadde
425. sokak
426. sokak
427. sokak
428. sokak
429. sokak
430. sokak
ARI KOLEJİ
EVRENSEL KOLEJ
PUBLIC PLAN


YÜZÜNCÜYIL İŞÇİ BLOKLARI MAHALLESİ
37. cadde
ARI KOLEJİ
EVRENSEL KOLEJ
DESIGN ALTERNATIVE-1
2X1250 KVA TRANSFORMERS CASE


YÜZÜNCÜYIL İŞÇİ BLOKLARI MAHALLESİ
37. cadde
EVRENSEL KOLEJ
ARI KOLEJİ
DESIGN ALTERNATIVE-2
4X630 kVA TRANSFORMERS CASE


YÜZÜNCÜYIL İŞÇİ BLOKLARI MAHALLESİ
37. cadde
425. sokak
426. sokak
427. sokak
428. sokak
429. sokak
430. sokak
ARI KOLEJİ
EVRENSEL KOLEJ
DESIGN ALTERNATIVE-3
8X315 kVA TRANSFORMERS CASE

THE CABLES BETWEEN BUILDINGS AND DISTRIBUTION BOXES (DESIGN ALTERNATIVE -1)

Line					Per Consumer			Diversified	Cable between DB and Building			Voltage Drop between DB and Building (V)		
TR	TR Line	Distribution Box	Building	Length (m)	Div. Max. Demand (VA)	Max. Demand (VA)	Max. Current (A)	Current per Building (A)	cross-section (mm2)	R (ohm/km)	X (ohm/km)	Voltage Drop (V)	Voltage Drop (%)	Max. per DB (V)
TR-1	Line-11	DB111	B129	17.08								1.38	0.60%	1.38
		DB112	B155	15.57								1.26	0.54%	4.88
			B156	10.48								0.85	0.37%	
			B246	60.46								4.88	2.11%	
		DB113	B250	19.06								1.54	0.67%	1.54
			B251	12.40								1.00	0.43%	
	Line-12	DB121	B130	17.32								1.40	0.61%	1.69
			B131	20.88								1.69	0.73%	
		DB122	B132	55.47								4.48	1.94%	4.48
			B133	17.66								1.43	0.62%	
			B134	37.77								3.05	1.32%	
			B252	37.06								2.99	1.30%	
	Line-13	DB131	B115	17.63								1.42	0.62%	3.26
			B116	40.39								3.26	1.41%	
		DB132	B113	34.87								2.82	1.22%	2.82
			B114	16.34								1.32	0.57%	
			B254	24.38								1.97	0.85%	
	Line-14	DB141	B117	13.90								1.12	0.49%	1.35
			B118	16.66								1.35	0.58%	
		DB142	B108	32.50								2.63	1.14%	2.63
			B109	13.30								1.07	0.47%	
			B110	20.63								1.67	0.72%	
		DB143	B111	13.53								1.09	0.47%	2.96
			B112	36.67								2.96	1.28%	
			B256	22.36								1.81	0.78%	
	Line-15	DB151	B119	24.29								1.96	0.85%	3.47
			B120	42.93								3.47	1.50%	
			B259	15.02								1.21	0.53%	
		DB152	B107	17.41								1.41	0.61%	2.08
			B257	12.30								0.99	0.43%	
			B258	25.71								2.08	0.90%	
		DB153	B104	32.10								2.59	1.12%	2.59
			B105	12.76								1.03	0.45%	
			B106	20.66								1.67	0.72%	
	Line-16	DB161	B102	31.87								2.57	1.11%	2.61
			B103	12.50								1.01	0.44%	
			B243	32.31								2.61	1.13%	
		DB162	B101	18.28								1.48	0.64%	2.15
			B241	26.62								2.15	0.93%	
			B242	10.31								0.83	0.36%	
	Line-17	DB171	B128	16.01								1.29	0.56%	1.29
		DB172	B126	35.37								2.86	1.24%	2.93
			B127	36.32								2.93	1.27%	
			B244	16.27								1.31	0.57%	
			B245	14.93								1.21	0.52%	
		DB173	B99	16.60								1.34	0.58%	1.54
			B100	19.10	2,000	5,000	7.60	47.86	(4x10)	1.830	0.094	1.54	0.67%	
TR-2	Line-21	DB211	B164	30.38								2.45	1.06%	2.45
			B165	10.95								0.88	0.38%	
			B166	22.11								1.79	0.77%	
		DB212	B138	20.24								1.64	0.71%	1.64
			B249	19.13								1.55	0.67%	
		DB213	B135	43.11								3.48	1.51%	3.48
			B136	22.12								1.79	0.77%	
			B137	25.54								2.06	0.89%	
	Line-22	DB221	B162	13.36								1.08	0.47%	1.14
			B163	14.14								1.14	0.49%	
		DB222	B141	27.62								2.23	0.97%	2.23
			B142	15.22								1.23	0.53%	
			B143	17.11								1.38	0.60%	
		DB223	B139	23.58								1.90	0.82%	1.90
			B140	20.13								1.63	0.70%	
	Line-23	DB231	B146	30.58								2.47	1.07%	2.47
			B147	13.40								1.08	0.47%	
			B148	27.54								2.22	0.96%	
		DB232	B144	13.12								1.06	0.46%	1.32
			B145	16.29								1.32	0.57%	
	Line-24	DB241	B159	16.59								1.34	0.58%	2.39
			B160	14.28								1.15	0.50%	
			B161	29.56								2.39	1.03%	
		DB242	B157	14.64								1.18	0.51%	1.35
			B158	16.71								1.35	0.58%	
	Line-25	DB251	B151	17.91								1.45	0.63%	1.45
			B152	16.67								1.35	0.58%	
		DB252	B153	20.12								1.63	0.70%	2.97
			B154	36.72								2.97	1.28%	
			B247	19.03								1.54	0.67%	
	Line-26	DB261	B248	9.97								0.81	0.35%	0.81
		DB262	B124	13.76								1.11	0.48%	4.26
			B125	34.20								2.76	1.20%	
			B240	52.75								4.26	1.85%	
		DB263	B97	14.23								1.15	0.50%	1.15
			B98	11.14								0.90	0.39%	
		DB264	B238	11.67								0.94	0.41%	1.70
			B239	21.03								1.70	0.74%	
	Line-27	DB271	B149	17.63								1.42	0.62%	1.42
			B150	14.64								1.18	0.51%	
		DB272	B122	14.98								1.21	0.52%	1.24
			B123	15.34								1.24	0.54%	
		DB273	B121	14.40								1.16	0.50%	1.90
			B236	23.47								1.90	0.82%	
		DB274	B96	27.77								2.24	0.97%	2.24
			B237	9.72								0.79	0.34%	
			B254	13.48								1.09	0.47%	
			Total Cable Length:	2,062.12									max:	4.88
			Max Length:	60.46									min:	0.81

THE CABLES BETWEEN BUILDINGS AND DISTRIBUTION BOXES (DESIGN ALTERNATIVE -2)

Line					Per Consumer			Diversified	Cable between DB and Building			Voltage Drop between DB and Building (V)		
TR	TR Line	Distribution Box	Building	Length (m)	Div. Max. Demand (VA)	Max. Demand (VA)	Max. Current (A)	Current per Building (A)	cross-section (mm2)	R (ohm/km)	X (ohm/km)			
TR-1	Line-11	DB111	B115	17.63	2,000	5,000	7.60	47.86	(4x10)	1.830	0.094	1.42	0.62%	3.26
			B116	40.39								3.26	1.41%	
	Line-11	DB112	B113	34.87								2.82	1.22%	2.82
			B114	16.34								1.32	0.57%	
			B254	24.38								1.97	0.85%	
	Line-12	DB121	B111	13.53								1.09	0.47%	2.96
			B112	36.67								2.96	1.28%	
			B256	22.36								1.81	0.78%	
	Line-12	DB122	B108	32.50								2.63	1.14%	2.63
			B109	13.30								1.07	0.47%	
			B110	20.63								1.67	0.72%	
	Line-13	DB131	B119	24.29								1.96	0.85%	3.47
			B120	42.93								3.47	1.50%	
			B259	15.02								1.21	0.53%	
	Line-13	DB132	B104	32.10								2.59	1.12%	2.59
			B105	12.76								1.03	0.45%	
			B106	20.66								1.67	0.72%	
	Line-14	DB141	B117	13.90								1.12	0.49%	1.35
			B118	16.66								1.35	0.58%	
	Line-14	DB142	B107	17.41								1.41	0.61%	2.08
			B257	12.30								0.99	0.43%	
			B258	25.71								2.08	0.90%	
TR-2	Line-21	DB211	B164	30.38								2.45	1.06%	2.45
			B165	10.95								0.88	0.38%	
			B166	22.11								1.79	0.77%	
	Line-21	DB212	B138	20.24								1.64	0.71%	1.64
			B249	19.13								1.55	0.67%	
	Line-22	DB221	B162	13.36								1.08	0.47%	1.14
			B163	14.14								1.14	0.49%	
	Line-22	DB222	B141	27.62								2.23	0.97%	2.23
			B142	15.22								1.23	0.53%	
			B143	17.11								1.38	0.60%	
	Line-22	DB223	B139	23.58								1.90	0.82%	1.90
			B140	20.13								1.63	0.70%	
	Line-23	DB231	B146	30.58								2.47	1.07%	2.47
			B147	13.40								1.08	0.47%	
			B148	27.54								2.22	0.96%	
	Line-24	DB232	B144	13.12								1.06	0.46%	1.32
			B145	16.29								1.32	0.57%	
	Line-24	DB241	B159	16.59								1.34	0.58%	2.39
			B160	14.28								1.15	0.50%	
			B161	29.56								2.39	1.03%	
	Line-24	DB242	B151	17.91								1.45	0.63%	1.45
			B152	16.67								1.35	0.58%	
	Line-25	DB251	B149	17.63								1.42	0.62%	1.42
			B150	14.64								1.18	0.51%	
	Line-25	DB252	B248	9.97								0.81	0.35%	0.81
TR-3	Line-31	DB311	B126	35.37								2.86	1.24%	2.93
			B127	36.32								2.93	1.27%	
			B244	16.27								1.31	0.57%	
			B245	14.93								1.21	0.52%	
	Line-32	DB321	B102	31.87								2.57	1.11%	2.61
			B103	12.50								1.01	0.44%	
			B243	32.31								2.61	1.13%	
	Line-33	DB331	B99	16.60								1.34	0.58%	1.54
			B100	19.10								1.54	0.67%	
	Line-33	DB332	B101	18.28								1.48	0.64%	2.15
			B241	26.62								2.15	0.93%	
			B242	10.31								0.83	0.36%	
	Line-34	DB341	B97	14.23								1.15	0.50%	1.15
			B98	11.14								0.90	0.39%	
	Line-34	DB342	B238	11.67								0.94	0.41%	1.70
			B239	21.03								1.70	0.74%	
	Line-35	DB351	B121	14.40								1.16	0.50%	1.90
			B236	23.47								1.90	0.82%	
	Line-35	DB352	B96	27.77								2.24	0.97%	2.24
			B237	9.72								0.79	0.34%	
			B254	13.48								1.09	0.47%	
	Line-36	DB361	B124	13.76								1.11	0.48%	4.26
			B125	34.20								2.76	1.20%	
			B240	52.75								4.26	1.85%	
	Line-36	DB362	B122	14.98								1.21	0.52%	1.24
			B123	15.34								1.24	0.54%	
TR-4	Line-41	DB411	B130	17.32								1.40	0.61%	1.69
			B131	20.88								1.69	0.73%	
	Line-41	DB412	B132	55.47								4.48	1.94%	4.48
			B133	17.66								1.43	0.62%	
			B134	37.77								3.05	1.32%	
			B252	37.06								2.99	1.30%	
	Line-42	DB421	B155	15.57								1.26	0.54%	4.88
			B156	10.48								0.85	0.37%	
			B246	60.46								4.88	2.11%	
	Line-42	DB422	B129	17.08								1.38	0.60%	1.38
	Line-42	DB423	B128	16.01								1.29	0.56%	1.29
	Line-43	DB431	B153	20.12								1.63	0.70%	2.97
			B154	36.72								2.97	1.28%	
			B247	19.03								1.54	0.67%	
	Line-43	DB432	B157	14.64								1.18	0.51%	1.35
			B158	16.71								1.35	0.58%	
	Line-44	DB441	B250	19.06								1.54	0.67%	1.54
			B251	12.40								1.00	0.43%	
	Line-44	DB442	B135	43.11								3.48	1.51%	3.48
			B136	22.12								1.79	0.77%	
			B137	25.54								2.06	0.89%	
			Total Cable Length:	2,062.12									max:	4.88
			Max Length:	60.46									min:	0.81

THE CABLES BETWEEN BUILDINGS AND DISTRIBUTION BOXES (DESIGN ALTERNATIVE -3)

Line					Per Consumer			Diversified	Cable between DB and Building			Voltage Drop between DB and Building (V)		
TR	TR Line	Distribution Box	Building	Length (m)	Div. Max. Demand (VA)	Max. Demand (VA)	Max. Current (A)	Current per Building (A)	cross-section (mm2)	R (ohm/km)	X (ohm/km)			
TR-1	Line-11	DB111	B132	55.47	2,000	5,000	7.60	47.86	(4x10)	1.830	0.094	4.48	1.94%	4.48
			B133	17.66								1.43	0.62%	
			B134	37.77								3.05	1.32%	
			B252	37.06								2.99	1.30%	
	Line-12	DB121	B113	34.87								2.82	1.22%	2.82
			B114	16.34								1.32	0.57%	
			B254	24.38								1.97	0.85%	
	Line-13	DB131	B111	13.53								1.09	0.47%	2.96
			B112	36.67								2.96	1.28%	
			B256	22.36								1.81	0.78%	
	Line-14	DB141	B130	17.32								1.40	0.61%	1.69
			B131	20.88								1.69	0.73%	
		DB142	B129	17.08								1.38	0.60%	1.38
TR-2	Line-21	DB211	B155	15.57								1.26	0.54%	4.88
			B156	10.48								0.85	0.37%	
			B246	60.46								4.88	2.11%	
	Line-22	DB221	B153	20.12								1.63	0.70%	2.97
			B154	36.72								2.97	1.28%	
			B247	19.03								1.54	0.67%	
		DB222	B151	17.91								1.45	0.63%	1.45
			B152	16.67								1.35	0.58%	
	Line-23	DB231	B250	19.06								1.54	0.67%	1.54
			B251	12.40								1.00	0.43%	
		DB232	B157	14.64								1.18	0.51%	1.35
			B158	16.71								1.35	0.58%	
TR-3	Line-31	DB311	B115	17.63								1.42	0.62%	3.26
			B116	40.39								3.26	1.41%	
	Line-32	DB321	B128	16.01								1.29	0.56%	1.29
		DB322	B126	35.37								2.86	1.24%	2.93
			B127	36.32								2.93	1.27%	
			B244	16.27								1.31	0.57%	
			B245	14.93								1.21	0.52%	
	Line-33	DB331	B117	13.90								1.12	0.49%	1.35
			B118	16.66								1.35	0.58%	
		DB332	B108	32.50								2.63	1.14%	2.63
			B109	13.30								1.07	0.47%	
			B110	20.63								1.67	0.72%	
TR-4	Line-41	DB411	B119	24.29								1.96	0.85%	3.47
			B120	42.93								3.47	1.50%	
			B259	15.02								1.21	0.53%	
		DB412	B107	17.41								1.41	0.61%	2.08
			B257	12.30								0.99	0.43%	
			B258	25.71								2.08	0.90%	
	Line-42	DB421	B102	31.87								2.57	1.11%	2.61
			B103	12.50								1.01	0.44%	
			B243	32.31								2.61	1.13%	
	Line-43	DB431	B104	32.10								2.59	1.12%	2.59
			B105	12.76								1.03	0.45%	
			B106	20.66								1.67	0.72%	
TR-5	Line-51	DB511	B99	16.60								1.34	0.58%	1.54
			B100	19.10								1.54	0.67%	
		DB512	B101	18.28								1.48	0.64%	2.15
			B241	26.62								2.15	0.93%	
			B242	10.31								0.83	0.36%	
	Line-52	DB521	B124	13.76								1.11	0.48%	4.26
			B125	34.20								2.76	1.20%	
			B240	52.75								4.26	1.85%	
	Line-53	DB531	B97	14.23								1.15	0.50%	1.15
			B98	11.14								0.90	0.39%	
		DB532	B238	11.67								0.94	0.41%	1.70
			B239	21.03								1.70	0.74%	
TR-6	Line-61	DB611	B248	9.97								0.81	0.35%	0.81
		DB612	B149	17.63								1.42	0.62%	1.42
			B150	14.64								1.18	0.51%	
	Line-62	DB621	B96	27.77								2.24	0.97%	2.24
			B237	9.72								0.79	0.34%	
			B254	13.48								1.09	0.47%	
	Line-63	DB631	B122	14.98								1.21	0.52%	1.24
			B123	15.34								1.24	0.54%	
		DB632	B121	14.40								1.16	0.50%	1.90
			B236	23.47								1.90	0.82%	
TR-7	Line-71	DB711	B159	16.59								1.34	0.58%	2.39
			B160	14.28								1.15	0.50%	
			B161	29.56								2.39	1.03%	
	Line-72	DB721	B146	30.58								2.47	1.07%	2.47
			B147	13.40								1.08	0.47%	
			B148	27.54								2.22	0.96%	
		DB722	B144	13.12								1.06	0.46%	1.32
			B145	16.29								1.32	0.57%	
	Line-73	DB731	B162	13.36								1.08	0.47%	1.14
			B163	14.14								1.14	0.49%	
		DB732	B141	27.62								2.23	0.97%	2.23
			B142	15.22								1.23	0.53%	
			B143	17.11								1.38	0.60%	
TR-8	Line-81	DB811	B138	20.24								1.64	0.71%	1.64
			B249	19.13								1.55	0.67%	
		DB812	B135	43.11								3.48	1.51%	3.48
			B136	22.12								1.79	0.77%	
			B137	25.54								2.06	0.89%	
	Line-82	DB821	B139	23.58								1.90	0.82%	1.90
			B140	20.13								1.63	0.70%	
	Line-83	DB831	B164	30.38								2.45	1.06%	2.45
			B165	10.95								0.88	0.38%	
			B166	22.11								1.79	0.77%	
			Total Cable Length:	2,062.12									max:	4.88
			Max Length:	60.46									min:	0.81

THE CABLES BETWEEN DISTRIBUTION BOXES AND BUILDINGS (DESIGN ALTERNATIVE -1)

Line						Number of Consumers		Diversity Factors		Per Consumer			Diversified Current (A)		Cable between TR & DB			Voltage Drop (volts)				
TR	Name	From	To	Length (m)						Div. Max. Demand (VA)	Max. Demand (VA)	Max. Current (A)			Cross-section (mm2)	R (ohm/km)	X (ohm/km)	between TR & DB		between DB & building	between TR & building	
TR-1	Line-11	TR-1	DB111	31.50	200.21	50	50	0.40	0.40	2,000	5,000	7.60	151.93	151.93	(3x50)+(1x25)	0.387	0.083	1.84	3.68%	1.38	3.22	1.39%
		DB111	DB112	95.33		40		0.41					124.59					4.57		4.88	11.29	4.89%
		DB112	DB113	73.38		20		0.49					74.45					2.10		1.54	10.05	4.35%
	Line-12	TR-1	DB121	62.20	171.63	60	60	0.40	0.40				182.32	182.32	(3x70)+(1x35)	0.268	0.080	3.13	2.99%	1.69	4.82	2.09%
		DB121	DB122	109.43		40		0.41					124.59					3.76		4.48	11.38	4.93%
	Line-13	TR-1	DB131	69.20	149.03	50	50	0.40	0.40				151.93	151.93	(3x50)+(1x25)	0.387	0.083	4.04	3.08%	3.26	7.31	3.16%
		DB131	DB132	79.83		30		0.44					100.28					3.08		2.82	9.94	4.30%
	Line-14	TR-1	DB141	32.22	196.28	80	80	0.40	0.40				243.09	243.09	(3x95)+(1x50)	0.193	0.079	1.63	2.95%	1.35	2.98	1.29%
		DB141	DB142	102.96		60		0.40					182.32					3.91		2.63	8.16	3.53%
		DB142	DB143	61.10		30		0.44					100.28					1.28		2.96	9.77	4.23%
	Line-15	TR-1	DB151	65.10	223.80	90	90	0.40	0.40				273.48	273.48	(3x95)+(1x50)	0.193	0.079	3.71	3.87%	3.47	7.17	3.11%
		DB151	DB152	112.22		60		0.40					182.32					4.26		2.08	10.04	4.35%
		DB152	DB153	46.48		30		0.44					100.28					0.97		2.59	11.53	4.99%
	Line-16	TR-1	DB161	148.06	195.66	80	80	0.40	0.40				243.09	243.09	(3x95)+(1x50)	0.193	0.079	7.49	3.90%	2.61	10.10	4.37%
		DB161	DB162	47.60		50		0.40					151.93					1.51		2.15	11.15	4.83%
	Line-17	TR-1	DB171	22.35	196.80	60	60	0.40	0.40				182.32	182.32	(3x35)+(1x16)	0.524	0.082	2.07	4.30%	1.29	3.36	1.46%
		DB171	DB172	97.28		30		0.44					100.28					4.95		2.93	9.95	4.31%
		DB172	DB173	77.17		20		0.49					74.45					2.91		1.54	11.47	4.97%
TR-2	Line-21	TR-2	DB211	64.08	221.62	80	80	0.40	0.40				243.09	243.09	(3x95)+(1x50)	0.193	0.079	3.24	3.29%	2.45	5.70	2.47%
		DB211	DB212	100.04		50		0.40					151.93					3.16		1.64	8.04	3.48%
		DB212	DB213	57.50		30		0.44					100.28					1.20		3.48	11.09	4.80%
	Line-22	TR-2	DB221	63.02	220.19	70	70	0.40	0.40				212.71	212.71	(3x70)+(1x35)	0.268	0.080	3.70	3.41%	1.14	4.84	2.10%
		DB221	DB222	44.39		50		0.40					151.93					1.86		2.23	7.79	3.37%
		DB222	DB223	112.78		20		0.49					74.45					2.32		1.90	9.79	4.24%
	Line-23	TR-2	DB231	53.90	111.13	50	50	0.40	0.40				151.93	151.93	(3x25)+(1x16)	0.727	0.086	5.67	3.73%	2.47	8.14	3.52%
		DB231	DB232	57.23		20		0.49					74.45					2.95		1.32	9.93	4.30%
	Line-24	TR-2	DB241	55.30	182.98	50	50	0.40	0.40				151.93	151.93	(3x35)+(1x16)	0.524	0.082	4.26	3.93%	2.39	6.65	2.88%
		DB241	DB242	127.68		20		0.49					74.45					4.82		1.35	10.44	4.52%
	Line-25	TR-2	DB251	60.55	112.44	50	50	0.40	0.40				151.93	151.93	(3x35)+(1x16)	0.524	0.082	4.67	3.16%	1.45	6.11	2.65%
		DB251	DB252	51.89		30		0.44					100.28					2.64		2.97	10.27	4.45%
	Line-26	TR-2	DB261	75.22	223.60	80	80	0.40	0.40				243.09	243.09	(3x95)+(1x50)	0.193	0.079	3.81	3.79%	0.81	4.61	2.00%
		DB261	DB262	77.48		70		0.40					212.71					3.43		4.26	11.50	4.98%
		DB262	DB263	39.90		40		0.41					124.59					1.03		1.15	9.42	4.08%
		DB263	DB264	31.00		20		0.49					74.45					0.48		1.70	10.45	4.52%
	Line-27	TR-2	DB271	62.78	227.28	90	90	0.40	0.40				273.48	273.48	(3x95)+(1x50)	0.193	0.079	3.57	4.02%	1.42	5.00	2.16%
		DB271	DB272	65.90		70		0.40					212.71					2.92		1.24	7.73	3.35%
		DB272	DB273	68.80		50		0.40					151.93					2.18		1.90	10.56	4.57%
		DB273	DB274	29.80		30		0.44					100.28					0.62		2.24	11.53	4.99%
		Total Cable Length:		2632.65									Max:	273.48				Max:	4.30%	4.88	11.53	4.99%
		Max. Cable Length:		227.28									Min:	151.93				Min:	2.95%	0.81	2.98	1.29%

THE CABLES BETWEEN DISTRIBUTION BOXES AND BUILDINGS (DESIGN ALTERNATIVE -2)

Line						Number of Consumers		Diversity Factors		Per Consumer			Diversified Current (A)		Cable between TR & DB			Voltage Drop (volts)				
TR	Name	From	To	Length (m)						Div. Max. Demand (VA)	Max. Demand (VA)	Max. Current (A)			Cross-section (mm2)	R (ohm/km)	X (ohm/km)	between TR & DB		between DB & building	between TR & building	
TR-1	Line-11	TR-1	DB111	58.25	137.95	50	50	0.40	0.40	2,000	5,000	7.60	151.93	151.93	(3X35)+(1X16)	0.524	0.082	4.49	3.70%	3.26	7.75	3.36%
		DB111	DB112	79.70		30		0.44					100.28					4.05		2.82	11.36	4.92%
	Line-12	TR-1	DB121	127.61	184.56	60	60	0.40	0.40				182.32	182.32	(3X70)+(1X35)	0.268	0.08	6.42	3.46%	2.96	9.39	4.06%
		DB121	DB122	56.95		30		0.44					100.28					1.58		2.63	10.63	4.60%
	Line-13	TR-1	DB131	63.40	163.06	60	60	0.40	0.40				182.32	182.32	(3X50)+(1X25)	0.387	0.083	4.44	3.59%	3.47	7.91	3.43%
		DB131	DB132	99.66		30		0.44					100.28					3.84		2.59	10.88	4.71%
	Line-14	TR-1	DB141	31.59	126.09	50	50	0.40	0.40				151.93	151.93	(3X35)+(1X16)	0.524	0.082	2.44	3.14%	1.35	3.78	1.64%
		DB141	DB142	94.50		30		0.44					100.28					4.81		2.08	9.32	4.04%
TR-2	Line-21	TR-2	DB211	64.08	164.48	50	50	0.40	0.40				151.93	151.93	(3X35)+(1X16)	0.524	0.082	4.94	3.78%	2.45	7.39	3.20%
		DB211	DB212	100.40		20		0.49					74.45					3.79		1.64	10.37	4.49%
	Line-22	TR-2	DB221	63.02		70		0.40					212.71					3.70		1.14	4.84	2.10%
		DB221	DB222	44.39	220.19	50	70	0.40	0.40				151.93	212.71	(3X70)+(1X35)	0.268	0.08	1.86	3.41%	2.23	7.79	3.37%
		DB222	DB223	112.78		20		0.49					74.45					2.32		1.90	9.79	4.24%
	Line-23	TR-2	DB231	53.90	111.13	50	50	0.40	0.40				151.93	151.93	(3X25)+(1X16)	0.727	0.086	5.67	3.73%	2.47	8.14	3.52%
		DB231	DB232	57.23		20		0.49					74.45					2.95		1.32	9.93	4.30%
	Line-24	TR-2	DB241	55.30	63.86	50	50	0.40	0.40				151.93	151.93	(3X16)+(1X10)	1.15	0.09	9.03	4.20%	2.39	11.41	4.94%
		DB241	DB242	8.56		20		0.49					74.45					0.68		1.45	11.16	4.83%
	Line-25	TR-2	DB251	62.78	91.13	30	30	0.44	0.44				100.28	100.28	(3X16)+(1X10)	1.15	0.09	6.76	3.56%	1.42	8.19	3.55%
		DB251	DB252	28.35		10		0.63					47.86					1.46		0.81	9.03	3.91%
TR-3	Line-31	TR-3	DB311	52.12	52.12	40	40	0.41	0.41				124.59	124.59	(3X16)+(1X10)	1.15	0.09	6.98	3.02%	2.93	9.91	4.29%
	Line-32	TR-3	DB321	63.07	63.07	30	30	0.44	0.44				100.28	100.28	(3X16)+(1X10)	1.15	0.09	6.79	2.94%	2.61	9.40	4.07%
	Line-33	TR-3	DB331	41.55	107.02	50	50	0.40	0.40				151.93	151.93	(3X25)+(1X16)	0.727	0.086	4.37		1.54	5.91	2.56%
		DB331	DB332	65.47		30		0.44					100.28					4.54	3.86%	2.15	11.06	4.79%
	Line-34	TR-3	DB341	77.44	109.71	40	40	0.41	0.41				124.59	124.59	(3X25)+(1X16)	0.727	0.086	6.67	3.61%	1.15	7.82	3.39%
		DB341	DB342	32.27		20		0.49					74.45					1.66		1.70	10.04	4.35%
	Line-35	TR-3	DB351	114.31	144.53	50	50	0.40	0.40				151.93	151.93	(3X50)+(1X25)	0.387	0.083	6.68	3.40%	1.90	8.57	3.71%
		DB351	DB352	30.22		30		0.44					100.28					1.17		2.24	10.09	4.37%
	Line-36	TR-3	DB361	65.95	111.07	50	50	0.40	0.40				151.93	151.93	(3X25)+(1X16)	0.727	0.086	6.93	4.01%	4.26	11.19	4.85%
		DB361	DB362	45.12		20		0.49					74.45					2.32		1.24	10.49	4.54%
TR-4	Line-41	TR-4	DB411	126.26	212.60	60	60	0.40	0.40				182.32	182.32	(3X95)+(1X50)	0.193	0.079	4.79	3.04%	1.69	6.48	2.81%
		DB411	DB412	86.34		40		0.41					124.59					2.24		4.48	11.51	4.98%
	Line-42	TR-4	DB421	34.23		50		0.40					151.93					3.60		4.88	8.48	3.67%
		DB421	DB422	93.15	178.74	20	50	0.49	0.40				74.45	151.93	(3X25)+(1X16)	0.727	0.086	4.80	4.37%	1.38	9.78	4.23%
		DB422	DB423	51.36		10		0.63					47.86					1.70		1.29	11.39	4.93%
	Line-43	TR-4	DB431	57.21	144.11	50	50	0.40	0.40				151.93	151.93	(3X35)+(1X16)	0.524	0.082	4.41		2.97	7.38	3.19%
		DB431	DB432	86.90		20		0.49					74.45					3.28	3.33%	1.35	9.04	3.92%
	Line-44	TR-4	DB441	41.42	175.66	50	50	0.40	0.40				151.93	151.93	(3X50)+(1X25)	0.387	0.083	2.42	3.29%	1.54	3.96	1.71%
		DB441	DB442	134.24		30		0.44					100.28					5.18		3.48	11.08	4.80%
		Total Cable Length:		2561.08									Max:	212.71				Max:	4.37%	4.88	11.51	4.98%
		Max. Cable Length:		220.19									Min:	100.28				Min:	2.94%	0.81	3.78	1.64%

THE CABLES BETWEEN DISTRIBUTION BOXES AND BUILDINGS (DESIGN ALTERNATIVE -3)

Line						Number of Consumers		Diversity Factors		Per Consumer			Diversified Current (A)		Cable between TR & DB			Voltage Drop (volts)				
TR	Name	From	To	Length (m)						Div. Max. Demand (VA)	Max. Demand (VA)	Max. Current (A)			Cross-section (mm2)	R (ohm/km)	X (ohm/km)	between TR & DB		between DB & building	between TR & building	
TR-1	Line-11	TR-1	DB111	67.40	67.40	40	40	0.41	0.41	2,000	5,000	7.60	124.59	124.59	(3X25)+(1X16)	0.727	0.086	5.81	2.52%	4.48	10.29	4.46%
	Line-12	TR-1	DB121	48.27	48.27	30	30	0.44	0.44				100.28	100.28	(3X16)+(1X10)	1.15	0.09	5.20	2.25%	2.82	8.02	3.47%
	Line-13	TR-1	DB131	116.98	116.98	30	30	0.44	0.44				100.28	100.28	(3X25)+(1X16)	0.727	0.086	8.11	3.51%	2.96	11.08	4.80%
	Line-14	TR-1	DB141	35.24	67.38	30	30	0.44	0.44				100.28	100.28	(3X16)+(1X10)	1.15	0.09	3.80	2.36%	1.69	5.48	2.37%
		DB141	DB142	32.14		10		0.63					47.86					1.65		1.38	6.83	2.96%
TR-2	Line-21	TR-2	DB211	35.56	35.56	30	30	0.44	0.44				100.28	100.28	(3X16)+(1X10)	1.15	0.09	3.83	1.66%	4.88	8.71	3.77%
	Line-22	TR-2	DB221	60.46	112.32	50	50	0.40	0.40				151.93	151.93	(3X25)+(1X16)	0.727	0.086	6.35	3.91%	2.97	9.32	4.04%
		DB221	DB222	51.86		20		0.49					74.45					2.67		1.45	10.47	4.53%
	Line-23	TR-1	DB231	43.83	82.70	40	40	0.41	0.41				124.59	124.59	(3X16)+(1X10)	1.15	0.09	5.87	3.89%	1.54	7.41	3.21%
		DB231	DB232	38.87		20		0.49					74.45					3.11		1.35	10.32	4.47%
TR-3	Line-31	TR-3	DB311	59.38	59.38	20	20	0.49	0.49				74.45	74.45	(3X16)+(1X10)	1.15	0.09	4.75	2.06%	3.26	8.01	3.47%
	Line-32	TR-3	DB321	32.41	129.28	50	50	0.40	0.40				151.93	151.93	(3X35)+(1X16)	0.524	0.082	2.50	3.73%	1.29	3.79	1.64%
		DB321	DB322	96.87		40		0.41					124.59					6.12		2.93	11.56	5.00%
	Line-33	TR-3	DB331	29.63	128.15	50	50	0.40	0.40				151.93	151.93	(3X35)+(1X16)	0.524	0.082	2.28	3.16%	1.35	3.63	1.57%
		DB331	DB332	98.52		30		0.44					100.28					5.01		2.63	9.92	4.30%
TR-4	Line-41	TR-4	DB411	45.43	103.66	60	60	0.40	0.40				182.32	182.32	(3X35)+(1X16)	0.524	0.082	4.20	3.10%	3.47	7.67	3.32%
		DB411	DB412	58.23		30		0.44					100.28					2.96		2.08	9.24	4.00%
	Line-42	TR-4	DB421	65.67	65.67	30	30	0.44	0.44				100.28	100.28	(3X16)+(1X10)	1.15	0.09	7.07	3.06%	2.61	9.68	4.19%
	Line-43	TR-4	DB431	103.31	103.31	30	30	0.40	0.40				91.16	91.16	(3X25)+(1X16)	0.727	0.086	6.52	2.82%	2.59	9.11	3.94%
TR-5	Line-51	TR-5	DB511	78.15	140.40	50	50	0.40	0.40				151.93	151.93	(3X35)+(1X16)	0.524	0.082	6.02	3.98%	1.54	7.57	3.28%
		DB511	DB512	62.25		30		0.44					100.28					3.17		2.15	11.34	4.91%
	Line-52	TR-5	DB521	32.05	32.05	30	30	0.44	0.44				100.28	100.28	(3X16)+(1X10)	1.15	0.09	3.45	1.49%	4.26	7.71	3.34%
	Line-53	TR-5	DB531	43.25	76.15	40	40	0.41	0.41				124.59	124.59	(3X16)+(1X10)	1.15	0.09	5.79	3.65%	1.15	6.94	3.00%
		DB531	DB532	32.90		20		0.49					74.45					2.63		1.70	10.12	4.38%
TR-6	Line-61	TR-6	DB611	29.32	62.41	30	30	0.44	0.44				100.28	100.28	(3X16)+(1X10)	1.15	0.09	3.16	2.51%	0.81	3.96	1.72%
		DB611	DB612	33.09		20		0.49					74.45					2.65		1.42	7.23	3.13%
	Line-62	TR-6	DB621	125.07	125.07	30	30	0.44	0.44				100.28	100.28	(3X25)+(1X16)	0.727	0.086	8.68	3.76%	2.24	10.92	4.73%
	Line-63	TR-6	DB631	26.04	94.71	40	40	0.41	0.41				124.59	124.59	(3X16)+(1X10)	1.15	0.09	3.49	3.89%	1.24	4.72	2.05%
		DB631	DB632	68.67		20		0.49					74.45					5.49		1.90	10.87	4.71%
TR-7	Line-71	TR-7	DB711	60.89	60.89	30	30	0.44	0.44				100.28	100.28	(3X16)+(1X10)	1.15	0.09	6.56	2.84%	2.39	8.95	3.87%
	Line-72	TR-7	DB721	40.72	98.15	50	50	0.40	0.40				151.93	151.93	(3X25)+(1X16)	0.727	0.086	4.28	3.13%	2.47	6.75	2.92%
		DB721	DB722	57.43		20		0.49					74.45					2.96		1.32	8.55	3.70%
	Line-73	TR-7	DB731	65.50	111.52	50	50	0.40	0.40				151.93	151.93	(3X35)+(1X16)	0.524	0.082	5.05	3.20%	1.14	6.19	2.68%
		DB731	DB732	46.02		30		0.44					100.28					2.34		2.23	9.62	4.17%
TR-8	Line-81	TR-8	DB811	58.54	119.69	50	50	0.40	0.40				151.93	151.93	(3X35)+(1X16)	0.524	0.082	4.51	3.30%	1.64	6.15	2.66%
		DB811	DB812	61.15		30		0.44					100.28					3.11		3.48	11.11	4.81%
	Line-82	TR-8	DB821	38.50	38.50	20	20	0.49	0.49				74.45	74.45	(3X16)+(1X10)	1.15	0.09	3.08	1.33%	1.90	4.98	2.16%
	Line-83	TR-8	DB831	38.31	38.31	30	30	0.44	0.44				100.28	100.28	(3X16)+(1X10)	1.15	0.09	4.13	1.79%	2.45	6.58	2.85%
			Total Cable Length:	2117.91									Max:	182.32				Max:	3.98%	4.88	11.56	5.00%
			Max. Cable Length:	140.4									Min:	74.45				Min:	1.33%	0.81	3.63	1.57%

APPANDIX C: LOSS CALCULATIONS

SUMMARY TABLE OF LOSS CALCULATIONS

Losses (kWh)		In 1st Year						In 20th Year						During 30 Years					
		Design Alt - 1		Design Alt - 2		Design Alt - 3		Design Alt - 1		Design Alt - 2		Design Alt - 3		Design Alt - 1		Design Alt - 2		Design Alt - 3	
Meters	voltage cct	8,234	96.41%	8,234	96.41%	8,234	96.41%	8,234	87.05%	8,234	87.05%	8,234	87.05%	247,032	88.14%	247,032	88.14%	247,032	88.14%
	current cct	307	3.59%	307	3.59%	307	3.59%	1,225	12.95%	1,225	12.95%	1,225	12.95%	33,236	11.86%	33,236	11.86%	33,236	11.86%
	total	8,541	100%	8,541	100%	8,541	100%	9,460	100%	9,460	100%	9,460	100%	280,268	100%	280,268	100%	280,268	100%
Cables	within building	5,529	21.47%	5,529	20.27%	5,529	21.47%	22,086	21.47%	22,086	20.27%	22,086	21.47%	599,059	21.47%	599,059	20.27%	599,059	21.47%
	between B&DB	3,517	13.66%	3,517	12.89%	3,517	13.65%	14,047	13.66%	14,047	12.89%	14,047	13.65%	380,993	13.66%	380,993	12.89%	380,993	13.65%
	between DB&TR	16,703	64.87%	18,232	66.84%	16,710	64.88%	66,718	64.87%	72,827	66.84%	66,747	64.88%	1,809,609	64.87%	1,975,319	66.84%	1,810,403	64.88%
	total	25,748	100%	27,278	100%	25,756	100%	102,851	100%	108,960	100%	102,880	100%	2,789,661	100%	2,955,372	100%	2,790,456	100%
TRs	no-load	34,164	88.99%	47,304	90.97%	57,466	90.30%	34,164	66.94%	47,304	71.61%	57,466	69.98%	1,024,920	69.13%	1,419,120	73.61%	1,723,968	72.06%
	load	4,225	11.01%	4,696	9.03%	6,171	9.70%	16,875	33.06%	18,758	28.39%	24,649	30.02%	457,720	30.87%	508,778	26.39%	668,555	27.94%
	total	38,389	100%	52,000	100%	63,636	100%	51,039	100%	66,062	100%	82,114	100%	1,482,640	100%	1,927,898	100%	2,392,523	100%
Total	meters	8,541	11.75%	8,541	9.73%	8,541	8.72%	9,460	5.79%	9,460	5.13%	9,460	4.86%	280,268	6.16%	280,268	5.43%	280,268	5.13%
	cables	25,748	35.43%	27,278	31.06%	25,756	26.30%	102,851	62.96%	108,960	59.06%	102,880	52.91%	2,789,661	61.28%	2,955,372	57.24%	2,790,456	51.08%
	TRs	38,389	52.82%	52,000	59.21%	63,636	64.98%	51,039	31.25%	66,062	35.81%	82,114	42.23%	1,482,640	32.57%	1,927,898	37.34%	2,392,523	43.79%
	total	72,678	100%	87,819	100%	97,933	100%	163,350	100%	184,482	100%	194,454	100%	4,552,569	100%	5,163,537	100%	5,463,246	100%
Total	no-load	42,398	58.34%	55,538	63.24%	65,700	67.09%	42,398	25.96%	55,538	30.11%	65,700	33.79%	1,271,952	27.94%	1,666,152	32.27%	1,971,000	36.08%
	load	30,280	41.66%	32,281	36.76%	32,233	32.91%	120,952	74.04%	128,944	69.89%	128,754	66.21%	3,280,617	72.06%	3,497,385	67.73%	3,492,246	63.92%
	total	72,678	100%	87,819	100%	97,933	100%	163,350	100%	184,482	100%	194,454	100%	4,552,569	100%	5,163,537	100%	5,463,246	100%
Consumption(kWh)		1,754,528		1,754,528		1,754,528		3,506,632		3,506,632		3,506,632		99,281,508		99,281,508		99,281,508	
Loss Ratio (%)		**4.14%**		**5.01%**		**5.58%**		**4.66%**		**5.26%**		**5.55%**		**4.59%**		**5.20%**		**5.50%**	
Cost of Losses (YTL)		11,722		14,163		15,795		26,345		29,753		31,362		734,238		832,775		881,112	
PV of Cost (YTL)		11,722		14,163		15,795		4,308		4,865		5,128		227,731		260,069		276,817	

LOSSES ON METERING DEVICES (per consumer) (in the first year)

Hour		Load Duration Curve (W)	Losses (Wh)						
			I (A)	Electronic Meter			Electromechanical Meter		
from	to			Current Cct	Voltage Cct	Total	Current Cct	Voltage Cct	Total
		A	B	C	D	E	F	G	H
			B=(A/0.9)/(380/√3)	C=(1x0.98)x(B/10)^2*0.25	D=1x0.25	E=C+D	F=(1.4x0.85)x(B/10)^{2}x0.25	G=0.9x0.25	H=F+G
00:00	00:15	2,250	11.39507	0.31813	0.25	0.56813	0.38630	0.225	0.61130
00:15	00:30	1,231	6.23437	0.09523	0.25	0.34523	0.11563	0.225	0.34063
00:30	00:45	1,229	6.22424	0.09492	0.25	0.34492	0.11526	0.225	0.34026
00:45	01:00	1,103	5.58612	0.07645	0.25	0.32645	0.09283	0.225	0.31783
01:00	01:15	1,003	5.07967	0.06322	0.25	0.31322	0.07676	0.225	0.30176
01:15	01:30	629	3.18556	0.02486	0.25	0.27486	0.03019	0.225	0.25519
01:30	01:45	501	2.53730	0.01577	0.25	0.26577	0.01915	0.225	0.24415
01:45	02:00	473	2.39550	0.01406	0.25	0.26406	0.01707	0.225	0.24207
02:00	02:15	436	2.20811	0.01195	0.25	0.26195	0.01451	0.225	0.23951
02:15	02:30	432	2.18785	0.01173	0.25	0.26173	0.01424	0.225	0.23924
02:30	02:45	432	2.18785	0.01173	0.25	0.26173	0.01424	0.225	0.23924
02:45	03:00	427	2.16253	0.01146	0.25	0.26146	0.01391	0.225	0.23891
03:00	03:15	427	2.16253	0.01146	0.25	0.26146	0.01391	0.225	0.23891
03:15	03:30	367	1.85866	0.00846	0.25	0.25846	0.01028	0.225	0.23528
03:30	03:45	367	1.85866	0.00846	0.25	0.25846	0.01028	0.225	0.23528
03:45	04:00	352	1.78270	0.00779	0.25	0.25779	0.00945	0.225	0.23445
04:00	04:15	329	1.66621	0.00680	0.25	0.25680	0.00826	0.225	0.23326
04:15	04:30	329	1.66621	0.00680	0.25	0.25680	0.00826	0.225	0.23326
04:30	04:45	313	1.58518	0.00616	0.25	0.25616	0.00748	0.225	0.23248
04:45	05:00	311	1.57505	0.00608	0.25	0.25608	0.00738	0.225	0.23238
05:00	05:15	307	1.55479	0.00592	0.25	0.25592	0.00719	0.225	0.23219
05:15	05:30	281	1.42312	0.00496	0.25	0.25496	0.00603	0.225	0.23103
05:30	05:45	281	1.42312	0.00496	0.25	0.25496	0.00603	0.225	0.23103
05:45	06:00	269	1.36234	0.00455	0.25	0.25455	0.00552	0.225	0.23052
06:00	06:15	269	1.36234	0.00455	0.25	0.25455	0.00552	0.225	0.23052
06:15	06:30	269	1.36234	0.00455	0.25	0.25455	0.00552	0.225	0.23052
06:30	06:45	252	1.27625	0.00399	0.25	0.25399	0.00485	0.225	0.22985
06:45	07:00	252	1.27625	0.00399	0.25	0.25399	0.00485	0.225	0.22985
07:00	07:15	252	1.27625	0.00399	0.25	0.25399	0.00485	0.225	0.22985
07:15	07:30	252	1.27625	0.00399	0.25	0.25399	0.00485	0.225	0.22985
07:30	07:45	252	1.27625	0.00399	0.25	0.25399	0.00485	0.225	0.22985
07:45	08:00	224	1.13444	0.00315	0.25	0.25315	0.00383	0.225	0.22883
08:00	08:15	213	1.07873	0.00285	0.25	0.25285	0.00346	0.225	0.22846
08:15	08:30	196	0.99264	0.00241	0.25	0.25241	0.00293	0.225	0.22793
08:30	08:45	194	0.98251	0.00237	0.25	0.25237	0.00287	0.225	0.22787
08:45	09:00	172	0.87109	0.00186	0.25	0.25186	0.00226	0.225	0.22726
09:00	09:15	169	0.85590	0.00179	0.25	0.25179	0.00218	0.225	0.22718
09:15	09:30	166	0.84070	0.00173	0.25	0.25173	0.00210	0.225	0.22710
09:30	09:45	149	0.75461	0.00140	0.25	0.25140	0.00169	0.225	0.22669
09:45	10:00	149	0.75461	0.00140	0.25	0.25140	0.00169	0.225	0.22669
10:00	10:15	138	0.69890	0.00120	0.25	0.25120	0.00145	0.225	0.22645
10:15	10:30	138	0.69890	0.00120	0.25	0.25120	0.00145	0.225	0.22645
10:30	10:45	129	0.65332	0.00105	0.25	0.25105	0.00127	0.225	0.22627
10:45	11:00	129	0.65332	0.00105	0.25	0.25105	0.00127	0.225	0.22627
11:00	11:15	129	0.65332	0.00105	0.25	0.25105	0.00127	0.225	0.22627
11:15	11:30	112	0.56722	0.00079	0.25	0.25079	0.00096	0.225	0.22596
11:30	11:45	104	0.52671	0.00068	0.25	0.25068	0.00083	0.225	0.22583
11:45	12:00	104	0.52671	0.00068	0.25	0.25068	0.00083	0.225	0.22583
12:00	12:15	94	0.47606	0.00056	0.25	0.25056	0.00067	0.225	0.22567
12:15	12:30	94	0.47606	0.00056	0.25	0.25056	0.00067	0.225	0.22567
12:30	12:45	94	0.47606	0.00056	0.25	0.25056	0.00067	0.225	0.22567
12:45	13:00	94	0.47606	0.00056	0.25	0.25056	0.00067	0.225	0.22567
13:00	13:15	84	0.42542	0.00044	0.25	0.25044	0.00054	0.225	0.22554
13:15	13:30	82	0.41529	0.00042	0.25	0.25042	0.00051	0.225	0.22551
13:30	13:45	82	0.41529	0.00042	0.25	0.25042	0.00051	0.225	0.22551

LOSSES ON METERING DEVICES (per consumer) (in the first year)

Hour		Load Duration Curve (W)	Losses (Wh)						
			I (A)	Electronic Meter			Electromechanical Meter		
from	to			Current Cct	Voltage Cct	Total	Current Cct	Voltage Cct	Total
		A	B	C	D	E	F	G	H
			B=(A/0.9)/(380/√3)	C=(1x0.98)x(B/10)^2*0.25	D=1x0.25	E=C+D	F=(1.4x0.85)x(B/10)^{2}x0.25	G=0.9x0.25	H=F+G
13:45	14:00	78	0.39503	0.00038	0.25	0.25038	0.00046	0.225	0.22546
14:00	14:15	67	0.33932	0.00028	0.25	0.25028	0.00034	0.225	0.22534
14:15	14:30	44	0.22284	0.00012	0.25	0.25012	0.00015	0.225	0.22515
14:30	14:45	44	0.22284	0.00012	0.25	0.25012	0.00015	0.225	0.22515
14:45	15:00	44	0.22284	0.00012	0.25	0.25012	0.00015	0.225	0.22515
15:00	15:15	38	0.19245	0.00009	0.25	0.25009	0.00011	0.225	0.22511
15:15	15:30	38	0.19245	0.00009	0.25	0.25009	0.00011	0.225	0.22511
15:30	15:45	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
15:45	16:00	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
16:00	16:15	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
16:15	16:30	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
16:30	16:45	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
16:45	17:00	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
17:00	17:15	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
17:15	17:30	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
17:30	17:45	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
17:45	18:00	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
18:00	18:15	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
18:15	18:30	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
18:30	18:45	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
18:45	19:00	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
19:00	19:15	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
19:15	19:30	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
19:30	19:45	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
19:45	20:00	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
20:00	20:15	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
20:15	20:30	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
20:30	20:45	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
20:45	21:00	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
21:00	21:15	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
21:15	21:30	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
21:30	21:45	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
21:45	22:00	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
22:00	22:15	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
22:15	22:30	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
22:30	22:45	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
22:45	23:00	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
23:00	23:15	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
23:15	23:30	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
23:30	23:45	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
23:45	00:00	29	0.14687	0.00005	0.25	0.25005	0.00006	0.225	0.22506
Total:		-	-	0.89	24.00	24.89	1.09	21.60	22.69

LOSSES ON CABLES WITHIN THE BUILDINGS (per building) (in the first year)

Hour		Load Duration Curve (W)	I (A)	R (ohm/m)	Losses (Wh)										
from	to				Flat 1	Flat 2	Flat 3	Flat 4	Flat 5	Flat 6	Flat 7	Flat 8	Flat 9	Flat 10	Total
		A	B	C	D	E	F	G	H	J	K	L	M	N	O
			B=(A/0.9)/(380/√3)		D=(B²x(Cx5)x0.25)x2	E=(B²x(Cx7)x0.25)x2	F=(B²x(Cx10)x0.25)x2	G=(B²x(Cx12)x0.25)x2	H=(B²x(Cx15)x0.25)x2	J=(B²x(Cx17)x0.25)x2	K=(B²x(Cx20)x0.25)x2	L=(B²x(Cx22)x0.25)x2	M=(B²x(Cx25)x0.25)x2	N=(B²x(Cx27)x0.25)x2	O=SUM(D:N)
00:00	00:15	2,250	11.39507	0.00552	1.79	2.51	3.58	4.30	5.38	6.09	7.17	7.88	8.96	9.68	57.34
00:15	00:30	1,231	6.23437	0.00552	0.54	0.75	1.07	1.29	1.61	1.82	2.15	2.36	2.68	2.90	17.16
00:30	00:45	1,229	6.22424	0.00552	0.53	0.75	1.07	1.28	1.60	1.82	2.14	2.35	2.67	2.89	17.11
00:45	01:00	1,103	5.58612	0.00552	0.43	0.60	0.86	1.03	1.29	1.46	1.72	1.89	2.15	2.33	13.78
01:00	01:15	1,003	5.07967	0.00552	0.36	0.50	0.71	0.85	1.07	1.21	1.42	1.57	1.78	1.92	11.39
01:15	01:30	629	3.18556	0.00552	0.14	0.20	0.28	0.34	0.42	0.48	0.56	0.62	0.70	0.76	4.48
01:30	01:45	501	2.53730	0.00552	0.09	0.12	0.18	0.21	0.27	0.30	0.36	0.39	0.44	0.48	2.84
01:45	02:00	473	2.39550	0.00552	0.08	0.11	0.16	0.19	0.24	0.27	0.32	0.35	0.40	0.43	2.53
02:00	02:15	436	2.20811	0.00552	0.07	0.09	0.13	0.16	0.20	0.23	0.27	0.30	0.34	0.36	2.15
02:15	02:30	432	2.18785	0.00552	0.07	0.09	0.13	0.16	0.20	0.22	0.26	0.29	0.33	0.36	2.11
02:30	02:45	432	2.18785	0.00552	0.07	0.09	0.13	0.16	0.20	0.22	0.26	0.29	0.33	0.36	2.11
02:45	03:00	427	2.16253	0.00552	0.06	0.09	0.13	0.15	0.19	0.22	0.26	0.28	0.32	0.35	2.07
03:00	03:15	427	2.16253	0.00552	0.06	0.09	0.13	0.15	0.19	0.22	0.26	0.28	0.32	0.35	2.07
03:15	03:30	367	1.85866	0.00552	0.05	0.07	0.10	0.11	0.14	0.16	0.19	0.21	0.24	0.26	1.53
03:30	03:45	367	1.85866	0.00552	0.05	0.07	0.10	0.11	0.14	0.16	0.19	0.21	0.24	0.26	1.53
03:45	04:00	352	1.78270	0.00552	0.04	0.06	0.09	0.11	0.13	0.15	0.18	0.19	0.22	0.24	1.40
04:00	04:15	329	1.66621	0.00552	0.04	0.05	0.08	0.09	0.11	0.13	0.15	0.17	0.19	0.21	1.23
04:15	04:30	329	1.66621	0.00552	0.04	0.05	0.08	0.09	0.11	0.13	0.15	0.17	0.19	0.21	1.23
04:30	04:45	313	1.58518	0.00552	0.03	0.05	0.07	0.08	0.10	0.12	0.14	0.15	0.17	0.19	1.11
04:45	05:00	311	1.57505	0.00552	0.03	0.05	0.07	0.08	0.10	0.12	0.14	0.15	0.17	0.18	1.10
05:00	05:15	307	1.55479	0.00552	0.03	0.05	0.07	0.08	0.10	0.11	0.13	0.15	0.17	0.18	1.07
05:15	05:30	281	1.42312	0.00552	0.03	0.04	0.06	0.07	0.08	0.10	0.11	0.12	0.14	0.15	0.89
05:30	05:45	281	1.42312	0.00552	0.03	0.04	0.06	0.07	0.08	0.10	0.11	0.12	0.14	0.15	0.89
05:45	06:00	269	1.36234	0.00552	0.03	0.04	0.05	0.06	0.08	0.09	0.10	0.11	0.13	0.14	0.82
06:00	06:15	269	1.36234	0.00552	0.03	0.04	0.05	0.06	0.08	0.09	0.10	0.11	0.13	0.14	0.82
06:15	06:30	269	1.36234	0.00552	0.03	0.04	0.05	0.06	0.08	0.09	0.10	0.11	0.13	0.14	0.82
06:30	06:45	252	1.27625	0.00552	0.02	0.03	0.04	0.05	0.07	0.08	0.09	0.10	0.11	0.12	0.72
06:45	07:00	252	1.27625	0.00552	0.02	0.03	0.04	0.05	0.07	0.08	0.09	0.10	0.11	0.12	0.72
07:00	07:15	252	1.27625	0.00552	0.02	0.03	0.04	0.05	0.07	0.08	0.09	0.10	0.11	0.12	0.72
07:15	07:30	252	1.27625	0.00552	0.02	0.03	0.04	0.05	0.07	0.08	0.09	0.10	0.11	0.12	0.72
07:30	07:45	252	1.27625	0.00552	0.02	0.03	0.04	0.05	0.07	0.08	0.09	0.10	0.11	0.12	0.72
07:45	08:00	224	1.13444	0.00552	0.02	0.02	0.04	0.04	0.05	0.06	0.07	0.08	0.09	0.10	0.57
08:00	08:15	213	1.07873	0.00552	0.02	0.02	0.03	0.04	0.05	0.05	0.06	0.07	0.08	0.09	0.51
08:15	08:30	196	0.99264	0.00552	0.01	0.02	0.03	0.03	0.04	0.05	0.05	0.06	0.07	0.07	0.44
08:30	08:45	194	0.98251	0.00552	0.01	0.02	0.03	0.03	0.04	0.05	0.05	0.06	0.07	0.07	0.43
08:45	09:00	172	0.87109	0.00552	0.01	0.01	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.34
09:00	09:15	169	0.85590	0.00552	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.32
09:15	09:30	166	0.84070	0.00552	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.31
09:30	09:45	149	0.75461	0.00552	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.25
09:45	10:00	149	0.75461	0.00552	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.25
10:00	10:15	138	0.69890	0.00552	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.22
10:15	10:30	138	0.69890	0.00552	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.22
10:30	10:45	129	0.65332	0.00552	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.19
10:45	11:00	129	0.65332	0.00552	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.19
11:00	11:15	129	0.65332	0.00552	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.19
11:15	11:30	112	0.56722	0.00552	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.14
11:30	11:45	104	0.52671	0.00552	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.12
11:45	12:00	104	0.52671	0.00552	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.12
12:00	12:15	94	0.47606	0.00552	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.10
12:15	12:30	94	0.47606	0.00552	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.10
12:30	12:45	94	0.47606	0.00552	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.10
12:45	13:00	94	0.47606	0.00552	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.10
13:00	13:15	84	0.42542	0.00552	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.08
13:15	13:30	82	0.41529	0.00552	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.08
13:30	13:45	82	0.41529	0.00552	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.08
13:45	14:00	78	0.39503	0.00552	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.07
14:00	14:15	67	0.33932	0.00552	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.05
14:15	14:30	44	0.22284	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
14:30	14:45	44	0.22284	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
14:45	15:00	44	0.22284	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
15:00	15:15	38	0.19245	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
15:15	15:30	38	0.19245	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
15:30	15:45	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
15:45	16:00	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
16:00	16:15	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
16:15	16:30	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
16:30	16:45	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
16:45	17:00	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
17:00	17:15	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
17:15	17:30	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
17:30	17:45	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
17:45	18:00	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
18:00	18:15	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
18:15	18:30	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
18:30	18:45	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
18:45	19:00	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
19:00	19:15	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
19:15	19:30	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
19:30	19:45	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
19:45	20:00	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
20:00	20:15	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
20:15	20:30	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01

LOSSES ON CABLES WITHIN THE BUILDINGS (per building) (in the first year)

Hour from	Hour to	Load Duration Curve (W)	I (A)	R (ohm/m)	Losses (Wh) Flat 1	Flat 2	Flat 3	Flat 4	Flat 5	Flat 6	Flat 7	Flat 8	Flat 9	Flat 10	Total
		A	B	C	D	E	F	G	H	J	K	L	M	N	O
			B=(A/0.9)/(380/√3)		D=(B^2x(Cx5)x0.25)x2	E=(B^2x(Cx7)x0.25)x2	F=(B^2x(Cx10)x0.25)x2	G=(B^2x(Cx12)x0.25)x2	H=(B^2x(Cx15)x0.25)x2	J=(B^2x(Cx17)x0.25)x2	K=(B^2x(Cx20)x0.25)x2	L=(B^2x(Cx22)x0.25)x2	M=(B^2x(Cx25)x0.25)x2	N=(B^2x(Cx27)x0.25)x2	O=SUM(D:N)
20:30	20:45	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
20:45	21:00	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
21:00	21:15	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
21:15	21:30	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
21:30	21:45	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
21:45	22:00	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
22:00	22:15	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
22:15	22:30	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
22:30	22:45	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
22:45	23:00	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
23:00	23:15	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
23:15	23:30	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
23:30	23:45	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
23:45	00:00	29	0.14687	0.00552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Total:		-	-	-	5.04	7.05	10.07	12.09	15.11	17.12	20.14	22.16	25.18	27.20	161.16

LOSSES ON THE CABLES BETWEEN BUILDINGS AND DISTRIBUTION BOXES (in the first year)

Line		Cable between DB and Building		Cable Reistance (ohm)	Current Square (I^2)	Daily Losses (Wh)
Building	Length (m)	cross-section (mm2)	R (ohm/km)			
	A	B	C	D	E	F
				D=AxC/1000	E=SUM(I^2)	F=3xDxEx0.25
B129	17.08	(4x10)	2.190	0.037405	2,844	79.80
B155	15.57	(4x10)	2.190	0.034098	2,844	72.74
B156	10.48	(4x10)	2.190	0.022951	2,844	48.96
B246	60.46	(4x10)	2.190	0.132407	2,844	282.47
B250	19.06	(4x10)	2.190	0.041741	2,844	89.05
B251	12.40	(4x10)	2.190	0.027156	2,844	57.93
B130	17.32	(4x10)	2.190	0.037931	2,844	80.92
B131	20.88	(4x10)	2.190	0.045727	2,844	97.55
B132	55.47	(4x10)	2.190	0.121479	2,844	259.16
B133	17.66	(4x10)	2.190	0.038675	2,844	82.51
B134	37.77	(4x10)	2.190	0.082716	2,844	176.46
B252	37.06	(4x10)	2.190	0.081161	2,844	173.15
B115	17.63	(4x10)	2.190	0.038610	2,844	82.37
B116	40.39	(4x10)	2.190	0.088454	2,844	188.70
B113	34.87	(4x10)	2.190	0.076365	2,844	162.91
B114	16.34	(4x10)	2.190	0.035785	2,844	76.34
B254	24.38	(4x10)	2.190	0.053392	2,844	113.90
B117	13.90	(4x10)	2.190	0.030441	2,844	64.94
B118	16.66	(4x10)	2.190	0.036485	2,844	77.84
B108	32.50	(4x10)	2.190	0.071175	2,844	151.84
B109	13.30	(4x10)	2.190	0.029127	2,844	62.14
B110	20.63	(4x10)	2.190	0.045180	2,844	96.38
B111	13.53	(4x10)	2.190	0.029631	2,844	63.21
B112	36.67	(4x10)	2.190	0.080307	2,844	171.32
B256	22.36	(4x10)	2.190	0.048968	2,844	104.47
B119	24.29	(4x10)	2.190	0.053195	2,844	113.48
B120	42.93	(4x10)	2.190	0.094017	2,844	200.57
B259	15.02	(4x10)	2.190	0.032894	2,844	70.17
B107	17.41	(4x10)	2.190	0.038128	2,844	81.34
B257	12.30	(4x10)	2.190	0.026937	2,844	57.47
B258	25.71	(4x10)	2.190	0.056305	2,844	120.12
B104	32.10	(4x10)	2.190	0.070299	2,844	149.97
B105	12.76	(4x10)	2.190	0.027944	2,844	59.62
B106	20.66	(4x10)	2.190	0.045245	2,844	96.52
B102	31.87	(4x10)	2.190	0.069795	2,844	148.90
B103	12.50	(4x10)	2.190	0.027375	2,844	58.40
B243	32.31	(4x10)	2.190	0.070759	2,844	150.95
B101	18.28	(4x10)	2.190	0.040033	2,844	85.41
B241	26.62	(4x10)	2.190	0.058298	2,844	124.37
B242	10.31	(4x10)	2.190	0.022579	2,844	48.17
B128	16.01	(4x10)	2.190	0.035062	2,844	74.80
B126	35.37	(4x10)	2.190	0.077460	2,844	165.25
B127	36.32	(4x10)	2.190	0.079541	2,844	169.69
B244	16.27	(4x10)	2.190	0.035631	2,844	76.01
B245	14.93	(4x10)	2.190	0.032697	2,844	69.75
B99	16.60	(4x10)	2.190	0.036354	2,844	77.56
B100	19.10	(4x10)	2.190	0.041829	2,844	89.24
B164	30.38	(4x10)	2.190	0.066532	2,844	141.94
B165	10.95	(4x10)	2.190	0.023981	2,844	51.16
B166	22.11	(4x10)	2.190	0.048421	2,844	103.30
B138	20.24	(4x10)	2.190	0.044326	2,844	94.56
B249	19.13	(4x10)	2.190	0.041895	2,844	89.38
B135	43.11	(4x10)	2.190	0.094411	2,844	201.41
B136	22.12	(4x10)	2.190	0.048443	2,844	103.35
B137	25.54	(4x10)	2.190	0.055933	2,844	119.32
B162	13.36	(4x10)	2.190	0.029258	2,844	62.42
B163	14.14	(4x10)	2.190	0.030967	2,844	66.06
B141	27.62	(4x10)	2.190	0.060488	2,844	129.04
B142	15.22	(4x10)	2.190	0.033332	2,844	71.11
B143	17.11	(4x10)	2.190	0.037471	2,844	79.94
B139	23.58	(4x10)	2.190	0.051640	2,844	110.17
B140	20.13	(4x10)	2.190	0.044085	2,844	94.05
B146	30.58	(4x10)	2.190	0.066970	2,844	142.87
B147	13.40	(4x10)	2.190	0.029346	2,844	62.61
B148	27.54	(4x10)	2.190	0.060313	2,844	128.67
B144	13.12	(4x10)	2.190	0.028733	2,844	61.30
B145	16.29	(4x10)	2.190	0.035675	2,844	76.11
B159	16.59	(4x10)	2.190	0.036332	2,844	77.51
B160	14.28	(4x10)	2.190	0.031273	2,844	66.72
B161	29.56	(4x10)	2.190	0.064736	2,844	138.11

LOSSES ON THE CABLES BETWEEN BUILDINGS AND DISTRIBUTION BOXES (in the first year)

Line		Cable between DB and Building		Cable Reistance (ohm)	Current Square (I^2)	Daily Losses (Wh)
Building	Length (m)	cross-section (mm2)	R (ohm/km)			
	A	B	C	D	E	F
				D=AxC/1000	E=SUM(I^2)	F=3xDxEx0.25
B157	14.64	(4x10)	2.190	0.032062	2,844	68.40
B158	16.71	(4x10)	2.190	0.036595	2,844	78.07
B151	17.91	(4x10)	2.190	0.039223	2,844	83.68
B152	16.67	(4x10)	2.190	0.036507	2,844	77.88
B153	20.12	(4x10)	2.190	0.044063	2,844	94.00
B154	36.72	(4x10)	2.190	0.080417	2,844	171.56
B247	19.03	(4x10)	2.190	0.041676	2,844	88.91
B248	9.97	(4x10)	2.190	0.021834	2,844	46.58
B124	13.76	(4x10)	2.190	0.030134	2,844	64.29
B125	34.20	(4x10)	2.190	0.074898	2,844	159.78
B240	52.75	(4x10)	2.190	0.115523	2,844	246.45
B97	14.23	(4x10)	2.190	0.031164	2,844	66.48
B98	11.14	(4x10)	2.190	0.024397	2,844	52.05
B238	11.67	(4x10)	2.190	0.025557	2,844	54.52
B239	21.03	(4x10)	2.190	0.046056	2,844	98.25
B149	17.63	(4x10)	2.190	0.038610	2,844	82.37
B150	14.64	(4x10)	2.190	0.032062	2,844	68.40
B122	14.98	(4x10)	2.190	0.032806	2,844	69.99
B123	15.34	(4x10)	2.190	0.033595	2,844	71.67
B121	14.40	(4x10)	2.190	0.031536	2,844	67.28
B236	23.47	(4x10)	2.190	0.051399	2,844	109.65
B96	27.77	(4x10)	2.190	0.060816	2,844	129.74
B237	9.72	(4x10)	2.190	0.021287	2,844	45.41
B254	13.48	(4x10)	2.190	0.029521	2,844	62.98
Total:	2,062.12				Total Losses:	9,634

LOSSES ON THE CABLES BETWEEN DISTRIBUTION BOXES AND BUILDINGS (DESIGN ALTERNATIVE -1) (in the first year)

TR	Name	From	To	Length (m) A	Length (m)	Number of Consumers B	Number of Consumers	Diversity Factors C	Diversity Factors	Cable between DB & TR: Cross-section (mm2)	Cable between DB & TR: R (ohm/km) D	Resistance (ohm) F	Current Square (I2) G	Daily Losses (Wh) H
												F=Dx(A/1000)	G=SUM(I2)	H=3xFxGx0.25
TR-1	Line-11	TR-1	DB111	31.50	200.21	50	50	0.40	0.40	(3x50)+(1x25)	0.463	0.014585	67,497	738.30
		DB111	DB112	95.33		40		0.41				0.044138	43,244	1431.52
		DB112	DB113	73.38		20		0.49				0.033975	10,948	278.97
	Line-12	TR-1	DB121	62.20	171.63	60	60	0.40	0.40	(3x70)+(1x35)	0.321	0.019966	97,195	1455.46
		DB121	DB122	109.43		40		0.41				0.035127	43,244	1139.27
	Line-13	TR-1	DB131	69.20	149.03	50	50	0.40	0.40	(3x50)+(1x25)	0.463	0.032040	67,497	1621.92
		DB131	DB132	79.83		30		0.44				0.036961	24,419	676.93
	Line-14	TR-1	DB141	32.22	196.28	80	80	0.40	0.40	(3x95)+(1x50)	0.232	0.007475	172,791	968.72
		DB141	DB142	102.96		60		0.40				0.023887	97,195	1741.25
		DB142	DB143	61.10		30		0.44				0.014175	24,419	259.61
	Line-15	TR-1	DB151	65.10	223.80	90	90	0.40	0.40	(3x95)+(1x50)	0.232	0.015103	218,689	2477.17
		DB151	DB152	112.22		60		0.40				0.026035	97,195	1897.86
		DB152	DB153	46.48		30		0.44				0.010783	24,419	197.49
	Line-16	TR-1	DB161	148.06	195.66	80	80	0.40	0.40	(3x95)+(1x50)	0.232	0.034350	172,791	4451.52
		DB161	DB162	47.60		50		0.40				0.011043	67,497	559.03
	Line-17	TR-1	DB171	22.35	196.80	60	60	0.40	0.40	(3x35)+(1x16)	0.627	0.014013	97,195	1021.53
		DB171	DB172	97.28		30		0.44				0.060995	24,419	1117.09
		DB172	DB173	77.17		20		0.49				0.048386	10,948	397.29
TR-2	Line-21	TR-2	DB211	64.08	221.62	80	80	0.40	0.40	(3x95)+(1x50)	0.232	0.014867	172,791	1926.61
		DB211	DB212	100.04		50		0.40				0.023209	67,497	1174.91
		DB212	DB213	57.50		30		0.44				0.013340	24,419	244.32
	Line-22	TR-2	DB221	63.02	220.19	70	70	0.40	0.40	(3x70)+(1x35)	0.321	0.020229	132,293	2007.16
		DB221	DB222	44.39		50		0.40				0.014249	67,497	721.33
		DB222	DB223	112.78		20		0.49				0.036202	10,948	297.26
	Line-23	TR-2	DB231	53.90	111.13	50	50	0.40	0.40	(3x25)+(1x16)	0.870	0.046893	67,497	2373.84
		DB231	DB232	57.23		20		0.49				0.049790	10,948	408.82
	Line-24	TR-2	DB241	55.30	182.98	50	50	0.40	0.40	(3x35)+(1x16)	0.627	0.034673	67,497	1755.24
		DB241	DB242	127.68		20		0.49				0.080055	10,948	657.33
	Line-25	TR-2	DB251	60.55	112.44	50	50	0.40	0.40	(3x35)+(1x16)	0.627	0.037965	67,497	1921.87
		DB251	DB252	51.89		30		0.44				0.032535	24,419	595.86
	Line-26	TR-2	DB261	75.22	223.60	80	80	0.40	0.40	(3x95)+(1x50)	0.232	0.017451	172,791	2261.54
		DB261	DB262	77.48		70		0.40				0.017975	132,293	1783.51
		DB262	DB263	39.90		40		0.41				0.009257	43,244	300.23
		DB263	DB264	31.00		20		0.49				0.007192	10,948	59.05
	Line-27	TR-2	DB271	62.78	227.28	90	90	0.40	0.40	(3x95)+(1x50)	0.232	0.014565	218,689	2388.89
		DB271	DB272	65.90		70		0.40				0.015289	132,293	1516.95
		DB272	DB273	68.80		50		0.40				0.015962	67,497	808.01
		DB273	DB274	29.80		30		0.44				0.006914	24,419	126.62
			Total Cable Length:		2,632.65								Total Daily Losses (Wh):	45,760.29

LOSSES ON THE CABLES BETWEEN DISTRIBUTION BOXES AND BUILDINGS (DESIGN ALTERNATIVE -2) (in the first year)

TR	Name	From	To	Length (m) A	Length (m)	Number of Consumers B	Number of Consumers	Diversity Factors C	Diversity Factors	Cable between DB & TR: Cross-section (mm2)	R (ohm/km) D	Resistance (ohm) F=Dx(A/1000)	Current Square (I2) G=SUM(I2)	Daily Losses (Wh) H=3xFxGx0.25
TR-1	Line-11	TR-1	DB111	58.25	137.95	50	50	0.40	0.40	(3X35)+(1X16)	0.627	0.036523	67,497	1848.87
		DB111	DB112	79.70		30		0.44				0.049972	24,419	915.21
	Line-12	TR-1	DB121	127.61	184.56	60	60	0.40	0.40	(3X70)+(1X35)	0.321	0.040963	97,195	2986.04
		DB121	DB122	56.95		30		0.44				0.018281	24,419	334.81
	Line-13	TR-1	DB131	63.40	163.06	60	60	0.40	0.40	(3X50)+(1X25)	0.463	0.029354	97,195	2139.81
		DB131	DB132	99.66		30		0.44				0.046143	24,419	845.08
	Line-14	TR-1	DB141	31.59	126.09	50	50	0.40	0.40	(3X35)+(1X16)	0.627	0.019807	67,497	1002.67
		DB141	DB142	94.50		30		0.44				0.059252	24,419	1085.17
TR-2	Line-21	TR-2	DB211	64.08	164.48	50	50	0.40	0.40	(3X35)+(1X16)	0.627	0.040178	67,497	2033.91
		DB211	DB212	100.40		20		0.49				0.062951	10,948	516.89
	Line-22	TR-2	DB221	63.02	220.19	70	70	0.40	0.40	(3X70)+(1X35)	0.321	0.020229	132,293	2007.16
		DB221	DB222	44.39		50		0.40				0.014249	67,497	721.33
		DB222	DB223	112.78		20		0.49				0.036202	10,948	297.26
	Line-23	TR-2	DB231	53.90	111.13	50	50	0.40	0.40	(3X25)+(1X16)	0.87	0.046893	67,497	2373.84
		DB231	DB232	57.23		20		0.49				0.049790	10,948	408.82
	Line-24	TR-2	DB241	55.30	63.86	50	50	0.40	0.40	(3X16)+(1X10)	1.38	0.076314	67,497	3863.20
		DB241	DB242	8.56		20		0.49				0.011813	10,948	96.99
	Line-25	TR-2	DB251	62.78	91.13	30	30	0.44	0.44	(3X16)+(1X10)	1.38	0.086636	24,419	1586.71
		DB251	DB252	28.35		10		0.63				0.039123	2,844	83.46
TR-3	Line-31	TR-3	DB311	52.12	52.12	40	40	0.41	0.41	(3X16)+(1X10)	1.38	0.071926	43,244	2332.76
	Line-32	TR-3	DB321	63.07	63.07	30	30	0.44	0.44	(3X16)+(1X10)	1.38	0.087037	24,419	1594.04
	Line-33	TR-3	DB331	41.55	107.02	50	50	0.40	0.40	(3X25)+(1X16)	0.87	0.036149	67,497	1829.92
		DB331	DB332	65.47		30		0.44				0.056959	24,419	1043.18
	Line-34	TR-3	DB341	77.44	109.71	40	40	0.41	0.41	(3X25)+(1X16)	0.87	0.067373	43,244	2185.10
		DB341	DB342	32.27		20		0.49				0.028075	10,948	230.52
	Line-35	TR-3	DB351	114.31	144.53	50	50	0.40	0.40	(3X50)+(1X25)	0.463	0.052926	67,497	2679.22
		DB351	DB352	30.22		30		0.44				0.013992	24,419	256.25
	Line-36	TR-3	DB361	65.95	111.07	50	50	0.40	0.40	(3X25)+(1X16)	0.87	0.057377	67,497	2904.54
		DB361	DB362	45.12		20		0.49				0.039254	10,948	322.32
TR-4	Line-41	TR-4	DB411	126.26	212.60	60	60	0.40	0.40	(3X95)+(1X50)	0.232	0.029292	97,195	2135.30
		DB411	DB412	86.34		40		0.41				0.020031	43,244	649.66
	Line-42	TR-4	DB421	34.23	178.74	50	50	0.40	0.40	(3X25)+(1X16)	0.87	0.029780	67,497	1507.54
		DB421	DB422	93.15		20		0.49				0.081041	10,948	665.42
		DB422	DB423	51.36		10		0.63				0.044683	2,844	95.33
	Line-43	TR-4	DB431	57.21	144.11	50	50	0.40	0.40	(3X35)+(1X16)	0.627	0.035871	67,497	1815.86
		DB431	DB432	86.90		20		0.49				0.054486	10,948	447.38
	Line-44	TR-4	DB441	41.42	175.66	50	50	0.40	0.40	(3X50)+(1X25)	0.463	0.019177	67,497	970.81
		DB441	DB442	134.24		30		0.44				0.062153	24,419	1138.31
			Total Cable Length:		2,561.08								Total Daily Losses (Wh):	49,950.67

LOSSES ON THE CABLES BETWEEN DISTRIBUTION BOXES AND BUILDINGS (DESIGN ALTERNATIVE -3) (in the first year)

TR	Line: Name	Line: From	Line: To	Length (m): A	Length (m)	Number of Consumers: B	Number of Consumers	Diversity Factors: C	Diversity Factors	Cable between DB & TR: Cross-section (mm2)	Cable between DB & TR: R (ohm/km) D	Resistance (ohm) F	Current Square (I2) G	Daily Losses (Wh) H
												F=Dx(A/1000)	G=SUM(I2)	H=3xFxGx0.25
TR-1	Line-11	TR-1	DB111	67.40	67.40	40	40	0.41	0.41	(3X25)+(1X16)	0.87	0.058638	43,244	1901.81
	Line-12	TR-1	DB121	48.27	48.27	30	30	0.44	0.44	(3X16)+(1X10)	1.38	0.066613	24,419	1219.98
	Line-13	TR-1	DB131	116.98	116.98	30	30	0.44	0.44	(3X25)+(1X16)	0.87	0.101773	24,419	1863.92
	Line-14	TR-1	DB141	35.24	67.38	30	30	0.44	0.44	(3X16)+(1X10)	1.38	0.048631	24,419	890.66
		DB141	DB142	32.14		10		0.63				0.044353	2,844	94.62
TR-2	Line-21	TR-2	DB211	35.56	35.56	30	30	0.44	0.44	(3X16)+(1X10)	1.38	0.049073	24,419	898.75
	Line-22	TR-2	DB221	60.46	112.32	50	50	0.40	0.40	(3X25)+(1X16)	0.87	0.052600	67,497	2662.75
		DB221	DB222	51.86		20		0.49				0.045118	10,948	370.46
	Line-23	TR-1	DB231	43.83	82.70	40	40	0.41	0.41	(3X16)+(1X10)	1.38	0.060485	43,244	1961.72
		DB231	DB232	38.87		20		0.49				0.053641	10,948	440.44
TR-3	Line-31	TR-3	DB311	59.38	59.38	20	20	0.49	0.49	(3X16)+(1X10)	1.38	0.081944	10,948	672.84
	Line-32	TR-3	DB321	32.41	129.28	50	50	0.40	0.40	(3X35)+(1X16)	0.627	0.020321	67,497	1028.70
		DB321	DB322	96.87		40		0.41				0.060737	43,244	1969.90
	Line-33	TR-3	DB331	29.63	128.15	50	50	0.40	0.40	(3X35)+(1X16)	0.627	0.018578	67,497	940.46
		DB331	DB332	98.52		30		0.44				0.061772	24,419	1131.33
TR-4	Line-41	TR-4	DB411	45.43	103.66	60	60	0.40	0.40	(3X35)+(1X16)	0.627	0.028485	97,195	2076.42
		DB411	DB412	58.23		30		0.44				0.036510	24,419	668.67
	Line-42	TR-4	DB421	65.67	65.67	30	30	0.44	0.44	(3X16)+(1X10)	1.38	0.090625	24,419	1659.75
	Line-43	TR-4	DB431	103.31	103.31	30	30	0.40	0.40	(3X25)+(1X16)	0.87	0.089880	24,419	1646.11
TR-5	Line-51	TR-5	DB511	78.15	140.40	50	50	0.40	0.40	(3X35)+(1X16)	0.627	0.049000	67,497	2480.50
		DB511	DB512	62.25		30		0.44				0.039031	24,419	714.83
	Line-52	TR-5	DB521	32.05	32.05	30	30	0.44	0.44	(3X16)+(1X10)	1.38	0.044229	24,419	810.03
	Line-53	TR-5	DB531	43.25	76.15	40	40	0.41	0.41	(3X16)+(1X10)	1.38	0.059685	43,244	1935.76
		DB531	DB532	32.90		20		0.49				0.045402	10,948	372.79
TR-6	Line-61	TR-6	DB611	29.32	62.41	30	30	0.44	0.44	(3X16)+(1X10)	1.38	0.040462	24,419	741.04
		DB611	DB612	33.09		20		0.49				0.045664	10,948	374.95
	Line-62	TR-6	DB621	125.07	125.07	30	30	0.44	0.44	(3X25)+(1X16)	0.87	0.108811	24,419	1992.82
	Line-63	TR-6	DB631	26.04	94.71	40	40	0.41	0.41	(3X16)+(1X10)	1.38	0.035935	43,244	1165.49
		DB631	DB632	68.67		20		0.49				0.094765	10,948	778.11
TR-7	Line-71	TR-7	DB711	60.89	60.89	30	30	0.44	0.44	(3X16)+(1X10)	1.38	0.084028	24,419	1538.94
	Line-72	TR-7	DB721	40.72	98.15	50	50	0.40	0.40	(3X25)+(1X16)	0.87	0.035426	67,497	1793.37
		DB721	DB722	57.43		20		0.49				0.049964	10,948	410.25
	Line-73	TR-7	DB731	65.50	111.52	50	50	0.40	0.40	(3X35)+(1X16)	0.627	0.041069	67,497	2078.99
		DB731	DB732	46.02		30		0.44				0.028855	24,419	528.46
TR-8	Line-81	TR-8	DB811	58.54	119.69	50	50	0.40	0.40	(3X35)+(1X16)	0.627	0.036705	67,497	1858.07
		DB811	DB812	61.15		30		0.44				0.038341	24,419	702.20
	Line-82	TR-8	DB821	38.50	38.50	20	20	0.49	0.49	(3X16)+(1X10)	1.38	0.053130	10,948	436.25
	Line-83	TR-8	DB831	38.31	38.31	30	30	0.44	0.44	(3X16)+(1X10)	1.38	0.052868	24,419	968.25
			Total Cable Length:		2,117.91								Total Daily Losses (Wh):	45,780.38

LOSSES ON THE TRANSFORMERS (DESIGN ALTERNATIVE -1) (in the first year)

Hour		TR-1		TR-2		Daily Load	Daily No-	Daily Total
from	to	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)	Losses (Wh)	Load Losses (Wh)	Losses (Wh)
		A	B	C	D	E	F	G
			$B=14000x((A/0.9)/1250000)^2x0.25$		$D=14000x((C/0.9)/1250000)^2x0.25$	E=B+D	F=1950x0.25 x2	G=E+F
00:00	00:15	423,000	494.82	423,000	494.82	989.63	975.00	1,964.63
00:15	00:30	349,716	338.22	349,716	338.22	676.43	975.00	1,651.43
00:30	00:45	349,716	338.22	349,716	338.22	676.43	975.00	1,651.43
00:45	01:00	349,716	338.22	349,716	338.22	676.43	975.00	1,651.43
01:00	01:15	349,716	338.22	349,716	338.22	676.43	975.00	1,651.43
01:15	01:30	349,716	338.22	349,716	338.22	676.43	975.00	1,651.43
01:30	01:45	349,716	338.22	349,716	338.22	676.43	975.00	1,651.43
01:45	02:00	349,716	338.22	349,716	338.22	676.43	975.00	1,651.43
02:00	02:15	349,716	338.22	349,716	338.22	676.43	975.00	1,651.43
02:15	02:30	349,716	338.22	349,716	338.22	676.43	975.00	1,651.43
02:30	02:45	349,716	338.22	349,716	338.22	676.43	975.00	1,651.43
02:45	03:00	349,716	338.22	349,716	338.22	676.43	975.00	1,651.43
03:00	03:15	349,716	338.22	349,716	338.22	676.43	975.00	1,651.43
03:15	03:30	134,914	50.34	134,914	50.34	100.67	975.00	1,075.67
03:30	03:45	134,914	50.34	134,914	50.34	100.67	975.00	1,075.67
03:45	04:00	134,914	50.34	134,914	50.34	100.67	975.00	1,075.67
04:00	04:15	134,914	50.34	134,914	50.34	100.67	975.00	1,075.67
04:15	04:30	134,914	50.34	134,914	50.34	100.67	975.00	1,075.67
04:30	04:45	134,914	50.34	134,914	50.34	100.67	975.00	1,075.67
04:45	05:00	134,914	50.34	134,914	50.34	100.67	975.00	1,075.67
05:00	05:15	134,914	50.34	134,914	50.34	100.67	975.00	1,075.67
05:15	05:30	134,914	50.34	134,914	50.34	100.67	975.00	1,075.67
05:30	05:45	134,914	50.34	134,914	50.34	100.67	975.00	1,075.67
05:45	06:00	134,914	50.34	134,914	50.34	100.67	975.00	1,075.67
06:00	06:15	134,914	50.34	134,914	50.34	100.67	975.00	1,075.67
06:15	06:30	134,914	50.34	134,914	50.34	100.67	975.00	1,075.67
06:30	06:45	134,914	50.34	134,914	50.34	100.67	975.00	1,075.67
06:45	07:00	134,914	50.34	134,914	50.34	100.67	975.00	1,075.67
07:00	07:15	134,914	50.34	134,914	50.34	100.67	975.00	1,075.67
07:15	07:30	134,914	50.34	134,914	50.34	100.67	975.00	1,075.67
07:30	07:45	134,914	50.34	134,914	50.34	100.67	975.00	1,075.67
07:45	08:00	134,914	50.34	134,914	50.34	100.67	975.00	1,075.67
08:00	08:15	134,914	50.34	134,914	50.34	100.67	975.00	1,075.67
08:15	08:30	51,133	7.23	51,133	7.23	14.46	975.00	989.46
08:30	08:45	51,133	7.23	51,133	7.23	14.46	975.00	989.46
08:45	09:00	51,133	7.23	51,133	7.23	14.46	975.00	989.46
09:00	09:15	51,133	7.23	51,133	7.23	14.46	975.00	989.46
09:15	09:30	51,133	7.23	51,133	7.23	14.46	975.00	989.46
09:30	09:45	51,133	7.23	51,133	7.23	14.46	975.00	989.46
09:45	10:00	51,133	7.23	51,133	7.23	14.46	975.00	989.46
10:00	10:15	51,133	7.23	51,133	7.23	14.46	975.00	989.46
10:15	10:30	51,133	7.23	51,133	7.23	14.46	975.00	989.46
10:30	10:45	51,133	7.23	51,133	7.23	14.46	975.00	989.46
10:45	11:00	51,133	7.23	51,133	7.23	14.46	975.00	989.46
11:00	11:15	51,133	7.23	51,133	7.23	14.46	975.00	989.46
11:15	11:30	51,133	7.23	51,133	7.23	14.46	975.00	989.46
11:30	11:45	51,133	7.23	51,133	7.23	14.46	975.00	989.46
11:45	12:00	51,133	7.23	51,133	7.23	14.46	975.00	989.46
12:00	12:15	51,133	7.23	51,133	7.23	14.46	975.00	989.46
12:15	12:30	51,133	7.23	51,133	7.23	14.46	975.00	989.46
12:30	12:45	51,133	7.23	51,133	7.23	14.46	975.00	989.46
12:45	13:00	51,133	7.23	51,133	7.23	14.46	975.00	989.46
13:00	13:15	51,133	7.23	51,133	7.23	14.46	975.00	989.46

LOSSES ON THE TRANSFORMERS (DESIGN ALTERNATIVE -1) (in the first year)

Hour		TR-1		TR-2		Daily Load Losses (Wh)	Daily No-Load Losses (Wh)	Daily Total Losses (Wh)
from	to	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)			
		A	B	C	D	E	F	G
			B=14000x((A/0.9)/1250000)^{2}x0.25		D=14000x((C/0.9)/1250000)^{2}x0.25	E=B+D	F=1950x0.25x2	G=E+F
13:15	13:30	51,133	7.23	51,133	7.23	14.46	975.00	989.46
13:30	13:45	51,133	7.23	51,133	7.23	14.46	975.00	989.46
13:45	14:00	51,133	7.23	51,133	7.23	14.46	975.00	989.46
14:00	14:15	51,133	7.23	51,133	7.23	14.46	975.00	989.46
14:15	14:30	51,133	7.23	51,133	7.23	14.46	975.00	989.46
14:30	14:45	51,133	7.23	51,133	7.23	14.46	975.00	989.46
14:45	15:00	51,133	7.23	51,133	7.23	14.46	975.00	989.46
15:00	15:15	51,133	7.23	51,133	7.23	14.46	975.00	989.46
15:15	15:30	51,133	7.23	51,133	7.23	14.46	975.00	989.46
15:30	15:45	13,630	0.51	13,630	0.51	1.03	975.00	976.03
15:45	16:00	13,630	0.51	13,630	0.51	1.03	975.00	976.03
16:00	16:15	13,630	0.51	13,630	0.51	1.03	975.00	976.03
16:15	16:30	13,630	0.51	13,630	0.51	1.03	975.00	976.03
16:30	16:45	13,630	0.51	13,630	0.51	1.03	975.00	976.03
16:45	17:00	13,630	0.51	13,630	0.51	1.03	975.00	976.03
17:00	17:15	13,630	0.51	13,630	0.51	1.03	975.00	976.03
17:15	17:30	13,630	0.51	13,630	0.51	1.03	975.00	976.03
17:30	17:45	13,630	0.51	13,630	0.51	1.03	975.00	976.03
17:45	18:00	13,630	0.51	13,630	0.51	1.03	975.00	976.03
18:00	18:15	13,630	0.51	13,630	0.51	1.03	975.00	976.03
18:15	18:30	13,630	0.51	13,630	0.51	1.03	975.00	976.03
18:30	18:45	13,630	0.51	13,630	0.51	1.03	975.00	976.03
18:45	19:00	13,630	0.51	13,630	0.51	1.03	975.00	976.03
19:00	19:15	13,630	0.51	13,630	0.51	1.03	975.00	976.03
19:15	19:30	13,630	0.51	13,630	0.51	1.03	975.00	976.03
19:30	19:45	13,630	0.51	13,630	0.51	1.03	975.00	976.03
19:45	20:00	13,630	0.51	13,630	0.51	1.03	975.00	976.03
20:00	20:15	13,630	0.51	13,630	0.51	1.03	975.00	976.03
20:15	20:30	13,630	0.51	13,630	0.51	1.03	975.00	976.03
20:30	20:45	13,630	0.51	13,630	0.51	1.03	975.00	976.03
20:45	21:00	13,630	0.51	13,630	0.51	1.03	975.00	976.03
21:00	21:15	13,630	0.51	13,630	0.51	1.03	975.00	976.03
21:15	21:30	13,630	0.51	13,630	0.51	1.03	975.00	976.03
21:30	21:45	13,630	0.51	13,630	0.51	1.03	975.00	976.03
21:45	22:00	13,630	0.51	13,630	0.51	1.03	975.00	976.03
22:00	22:15	13,630	0.51	13,630	0.51	1.03	975.00	976.03
22:15	22:30	13,630	0.51	13,630	0.51	1.03	975.00	976.03
22:30	22:45	13,630	0.51	13,630	0.51	1.03	975.00	976.03
22:45	23:00	13,630	0.51	13,630	0.51	1.03	975.00	976.03
23:00	23:15	13,630	0.51	13,630	0.51	1.03	975.00	976.03
23:15	23:30	13,630	0.51	13,630	0.51	1.03	975.00	976.03
23:30	23:45	13,630	0.51	13,630	0.51	1.03	975.00	976.03
23:45	00:00	13,630	0.51	13,630	0.51	1.03	975.00	976.03
Total:		-	5,787.27	-	5,787.27	11,574.54	93,600.00	105,174.54

LOSSES ON THE TRANSFORMERS (DESIGN ALTERNATIVE -2) (in the first year)

Hour		TR-1		TR-2		TR-3		TR-4		Daily Load Losses (Wh)	Daily No-Load Losses (Wh)	Daily Total Losses (Wh)
from	to	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)			
		A	B	C	D	E	F	G	H	I	J	K
			$B=8000x((A/0.9)/630000)^2x0.25$		$D=8000x((C/0.9)/630000)^2x0.25$		$F=8000x((E/0.9)/630000)^2x0.25$		$H=8000x((G/0.9)/630000)^2x0.25$	I=B+D+F+H	J=1350x0.25x4	K=I+J
00:00	00:15	189,000	222.22	225,000	314.94	234,000	340.64	189,000	222.22	1,100.03	1,350.00	2,450.03
00:15	00:30	156,256	151.89	186,019	215.27	193,460	232.83	156,256	151.89	751.89	1,350.00	2,101.89
00:30	00:45	156,256	151.89	186,019	215.27	193,460	232.83	156,256	151.89	751.89	1,350.00	2,101.89
00:45	01:00	156,256	151.89	186,019	215.27	193,460	232.83	156,256	151.89	751.89	1,350.00	2,101.89
01:00	01:15	156,256	151.89	186,019	215.27	193,460	232.83	156,256	151.89	751.89	1,350.00	2,101.89
01:15	01:30	156,256	151.89	186,019	215.27	193,460	232.83	156,256	151.89	751.89	1,350.00	2,101.89
01:30	01:45	156,256	151.89	186,019	215.27	193,460	232.83	156,256	151.89	751.89	1,350.00	2,101.89
01:45	02:00	156,256	151.89	186,019	215.27	193,460	232.83	156,256	151.89	751.89	1,350.00	2,101.89
02:00	02:15	156,256	151.89	186,019	215.27	193,460	232.83	156,256	151.89	751.89	1,350.00	2,101.89
02:15	02:30	156,256	151.89	186,019	215.27	193,460	232.83	156,256	151.89	751.89	1,350.00	2,101.89
02:30	02:45	156,256	151.89	186,019	215.27	193,460	232.83	156,256	151.89	751.89	1,350.00	2,101.89
02:45	03:00	156,256	151.89	186,019	215.27	193,460	232.83	156,256	151.89	751.89	1,350.00	2,101.89
03:00	03:15	156,256	151.89	186,019	215.27	193,460	232.83	156,256	151.89	751.89	1,350.00	2,101.89
03:15	03:30	60,281	22.61	71,763	32.04	74,633	34.65	60,281	22.61	111.90	1,350.00	1,461.90
03:30	03:45	60,281	22.61	71,763	32.04	74,633	34.65	60,281	22.61	111.90	1,350.00	1,461.90
03:45	04:00	60,281	22.61	71,763	32.04	74,633	34.65	60,281	22.61	111.90	1,350.00	1,461.90
04:00	04:15	60,281	22.61	71,763	32.04	74,633	34.65	60,281	22.61	111.90	1,350.00	1,461.90
04:15	04:30	60,281	22.61	71,763	32.04	74,633	34.65	60,281	22.61	111.90	1,350.00	1,461.90
04:30	04:45	60,281	22.61	71,763	32.04	74,633	34.65	60,281	22.61	111.90	1,350.00	1,461.90
04:45	05:00	60,281	22.61	71,763	32.04	74,633	34.65	60,281	22.61	111.90	1,350.00	1,461.90
05:00	05:15	60,281	22.61	71,763	32.04	74,633	34.65	60,281	22.61	111.90	1,350.00	1,461.90
05:15	05:30	60,281	22.61	71,763	32.04	74,633	34.65	60,281	22.61	111.90	1,350.00	1,461.90
05:30	05:45	60,281	22.61	71,763	32.04	74,633	34.65	60,281	22.61	111.90	1,350.00	1,461.90
05:45	06:00	60,281	22.61	71,763	32.04	74,633	34.65	60,281	22.61	111.90	1,350.00	1,461.90
06:00	06:15	60,281	22.61	71,763	32.04	74,633	34.65	60,281	22.61	111.90	1,350.00	1,461.90
06:15	06:30	60,281	22.61	71,763	32.04	74,633	34.65	60,281	22.61	111.90	1,350.00	1,461.90
06:30	06:45	60,281	22.61	71,763	32.04	74,633	34.65	60,281	22.61	111.90	1,350.00	1,461.90
06:45	07:00	60,281	22.61	71,763	32.04	74,633	34.65	60,281	22.61	111.90	1,350.00	1,461.90
07:00	07:15	60,281	22.61	71,763	32.04	74,633	34.65	60,281	22.61	111.90	1,350.00	1,461.90
07:15	07:30	60,281	22.61	71,763	32.04	74,633	34.65	60,281	22.61	111.90	1,350.00	1,461.90
07:30	07:45	60,281	22.61	71,763	32.04	74,633	34.65	60,281	22.61	111.90	1,350.00	1,461.90
07:45	08:00	60,281	22.61	71,763	32.04	74,633	34.65	60,281	22.61	111.90	1,350.00	1,461.90
08:00	08:15	60,281	22.61	71,763	32.04	74,633	34.65	60,281	22.61	111.90	1,350.00	1,461.90
08:15	08:30	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
08:30	08:45	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
08:45	09:00	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
09:00	09:15	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
09:15	09:30	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
09:30	09:45	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
09:45	10:00	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
10:00	10:15	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
10:15	10:30	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07

LOSSES ON THE TRANSFORMERS (DESIGN ALTERNATIVE -2) (in the first year)

Hour		TR-1		TR-2		TR-3		TR-4		Daily Load Losses (Wh)	Daily No-Load Losses (Wh)	Daily Total Losses (Wh)
from	to	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)			
		A	B	C	D	E	F	G	H	I	J	K
			$B=8000x((A/0.9)/630000)^2x0.25$		$D=8000x((C/0.9)/630000)^2x0.25$		$F=8000x((E/0.9)/630000)^2x0.25$		$H=8000x((G/0.9)/630000)^2x0.25$	I=B+D+F+H	J=1350x0.25x4	K=I+J
10:30	10:45	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
10:45	11:00	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
11:00	11:15	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
11:15	11:30	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
11:30	11:45	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
11:45	12:00	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
12:00	12:15	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
12:15	12:30	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
12:30	12:45	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
12:45	13:00	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
13:00	13:15	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
13:15	13:30	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
13:30	13:45	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
13:45	14:00	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
14:00	14:15	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
14:15	14:30	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
14:30	14:45	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
14:45	15:00	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
15:00	15:15	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
15:15	15:30	22,847	3.25	27,198	4.60	28,286	4.98	22,847	3.25	16.07	1,350.00	1,366.07
15:30	15:45	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
15:45	16:00	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
16:00	16:15	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
16:15	16:30	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
16:30	16:45	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
16:45	17:00	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
17:00	17:15	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
17:15	17:30	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
17:30	17:45	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
17:45	18:00	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
18:00	18:15	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
18:15	18:30	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
18:30	18:45	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
18:45	19:00	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
19:00	19:15	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
19:15	19:30	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
19:30	19:45	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
19:45	20:00	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
20:00	20:15	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
20:15	20:30	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
20:30	20:45	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
20:45	21:00	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14

LOSSES ON THE TRANSFORMERS (DESIGN ALTERNATIVE -2) (in the first year)

Hour		TR-1		TR-2		TR-3		TR-4		Daily Load Losses (Wh)	Daily No-Load Losses (Wh)	Daily Total Losses (Wh)
from	to	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)			
		A	B	C	D	E	F	G	H	I	J	K
			B=8000x((A/0.9)/630000)^{2}x0.25		D=8000x((C/0.9)/630000)^{2}x0.25		F=8000x((E/0.9)/630000)^{2}x0.25		H=8000x((G/0.9)/630000)^{2}x0.25	I=B+D+F+H	J=1350x0.25x4	K=I+J
21:00	21:15	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
21:15	21:30	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
21:30	21:45	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
21:45	22:00	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
22:00	22:15	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
22:15	22:30	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
22:30	22:45	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
22:45	23:00	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
23:00	23:15	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
23:15	23:30	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
23:30	23:45	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
23:45	00:00	6,090	0.23	7,250	0.33	7,540	0.35	6,090	0.23	1.14	1,350.00	1,351.14
Total:		-	2,599	-	3,683	-	3,984	-	2,599	12,865.67	129,600.00	142,465.67

LOSSES ON THE TRANSFORMERS (DESIGN ALTERNATIVE -3) (in the first year)

Hour		TR-1		TR-2		TR-3		TR-4		TR-5		TR-6		TR-7		TR-8		Daily Load Losses (Wh)	Daily No-Load Losses (Wh)	Daily Total Losses (Wh)
from	to	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)			
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R	S	T
			B=5150x((A/0.9)/315000)^{2}x0.25		D=5150x((C/0.9)/315000)^{2}x0.25		F=5150x((E/0.9)/315000)^{2}x0.25		H=5150x((G/0.9)/315000)^{2}x0.25		J=5150x((I/0.9)/315000)^{2}x0.25		L=5150x((K/0.9)/315000)^{2}x0.25		N=5150x((M/0.9)/315000)^{2}x0.25		P=5150x((O/0.9)/315000)^{2}x0.25	R=B+D+F+H+J+L+N+P	S=825x0.25X8	T=R+S
00:00	00:15	117,000	219.29	108,000	186.85	108,000	186.85	108,000	186.85	108,000	186.85	90,000	129.76	117,000	219.29	90,000	129.76	1,445.48	1,640.00	3,085.48
00:15	00:30	96,730	149.89	89,289	127.71	89,289	127.71	89,289	127.71	89,289	127.71	74,408	88.69	96,730	149.89	74,408	88.69	988.01	1,640.00	2,628.01
00:30	00:45	96,730	149.89	89,289	127.71	89,289	127.71	89,289	127.71	89,289	127.71	74,408	88.69	96,730	149.89	74,408	88.69	988.01	1,640.00	2,628.01
00:45	01:00	96,730	149.89	89,289	127.71	89,289	127.71	89,289	127.71	89,289	127.71	74,408	88.69	96,730	149.89	74,408	88.69	988.01	1,640.00	2,628.01
01:00	01:15	96,730	149.89	89,289	127.71	89,289	127.71	89,289	127.71	89,289	127.71	74,408	88.69	96,730	149.89	74,408	88.69	988.01	1,640.00	2,628.01
01:15	01:30	96,730	149.89	89,289	127.71	89,289	127.71	89,289	127.71	89,289	127.71	74,408	88.69	96,730	149.89	74,408	88.69	988.01	1,640.00	2,628.01
01:30	01:45	96,730	149.89	89,289	127.71	89,289	127.71	89,289	127.71	89,289	127.71	74,408	88.69	96,730	149.89	74,408	88.69	988.01	1,640.00	2,628.01
01:45	02:00	96,730	149.89	89,289	127.71	89,289	127.71	89,289	127.71	89,289	127.71	74,408	88.69	96,730	149.89	74,408	88.69	988.01	1,640.00	2,628.01
02:00	02:15	96,730	149.89	89,289	127.71	89,289	127.71	89,289	127.71	89,289	127.71	74,408	88.69	96,730	149.89	74,408	88.69	988.01	1,640.00	2,628.01
02:15	02:30	96,730	149.89	89,289	127.71	89,289	127.71	89,289	127.71	89,289	127.71	74,408	88.69	96,730	149.89	74,408	88.69	988.01	1,640.00	2,628.01
02:30	02:45	96,730	149.89	89,289	127.71	89,289	127.71	89,289	127.71	89,289	127.71	74,408	88.69	96,730	149.89	74,408	88.69	988.01	1,640.00	2,628.01
02:45	03:00	96,730	149.89	89,289	127.71	89,289	127.71	89,289	127.71	89,289	127.71	74,408	88.69	96,730	149.89	74,408	88.69	988.01	1,640.00	2,628.01
03:00	03:15	96,730	149.89	89,289	127.71	89,289	127.71	89,289	127.71	89,289	127.71	74,408	88.69	96,730	149.89	74,408	88.69	988.01	1,640.00	2,628.01
03:15	03:30	37,317	22.31	34,446	19.01	34,446	19.01	34,446	19.01	34,446	19.01	28,705	13.20	37,317	22.31	28,705	13.20	147.04	1,640.00	1,787.04
03:30	03:45	37,317	22.31	34,446	19.01	34,446	19.01	34,446	19.01	34,446	19.01	28,705	13.20	37,317	22.31	28,705	13.20	147.04	1,640.00	1,787.04
03:45	04:00	37,317	22.31	34,446	19.01	34,446	19.01	34,446	19.01	34,446	19.01	28,705	13.20	37,317	22.31	28,705	13.20	147.04	1,640.00	1,787.04
04:00	04:15	37,317	22.31	34,446	19.01	34,446	19.01	34,446	19.01	34,446	19.01	28,705	13.20	37,317	22.31	28,705	13.20	147.04	1,640.00	1,787.04
04:15	04:30	37,317	22.31	34,446	19.01	34,446	19.01	34,446	19.01	34,446	19.01	28,705	13.20	37,317	22.31	28,705	13.20	147.04	1,640.00	1,787.04
04:30	04:45	37,317	22.31	34,446	19.01	34,446	19.01	34,446	19.01	34,446	19.01	28,705	13.20	37,317	22.31	28,705	13.20	147.04	1,640.00	1,787.04
04:45	05:00	37,317	22.31	34,446	19.01	34,446	19.01	34,446	19.01	34,446	19.01	28,705	13.20	37,317	22.31	28,705	13.20	147.04	1,640.00	1,787.04
05:00	05:15	37,317	22.31	34,446	19.01	34,446	19.01	34,446	19.01	34,446	19.01	28,705	13.20	37,317	22.31	28,705	13.20	147.04	1,640.00	1,787.04
05:15	05:30	37,317	22.31	34,446	19.01	34,446	19.01	34,446	19.01	34,446	19.01	28,705	13.20	37,317	22.31	28,705	13.20	147.04	1,640.00	1,787.04
05:30	05:45	37,317	22.31	34,446	19.01	34,446	19.01	34,446	19.01	34,446	19.01	28,705	13.20	37,317	22.31	28,705	13.20	147.04	1,640.00	1,787.04
05:45	06:00	37,317	22.31	34,446	19.01	34,446	19.01	34,446	19.01	34,446	19.01	28,705	13.20	37,317	22.31	28,705	13.20	147.04	1,640.00	1,787.04
06:00	06:15	37,317	22.31	34,446	19.01	34,446	19.01	34,446	19.01	34,446	19.01	28,705	13.20	37,317	22.31	28,705	13.20	147.04	1,640.00	1,787.04
06:15	06:30	37,317	22.31	34,446	19.01	34,446	19.01	34,446	19.01	34,446	19.01	28,705	13.20	37,317	22.31	28,705	13.20	147.04	1,640.00	1,787.04
06:30	06:45	37,317	22.31	34,446	19.01	34,446	19.01	34,446	19.01	34,446	19.01	28,705	13.20	37,317	22.31	28,705	13.20	147.04	1,640.00	1,787.04
06:45	07:00	37,317	22.31	34,446	19.01	34,446	19.01	34,446	19.01	34,446	19.01	28,705	13.20	37,317	22.31	28,705	13.20	147.04	1,640.00	1,787.04
07:00	07:15	37,317	22.31	34,446	19.01	34,446	19.01	34,446	19.01	34,446	19.01	28,705	13.20	37,317	22.31	28,705	13.20	147.04	1,640.00	1,787.04
07:15	07:30	37,317	22.31	34,446	19.01	34,446	19.01	34,446	19.01	34,446	19.01	28,705	13.20	37,317	22.31	28,705	13.20	147.04	1,640.00	1,787.04
07:30	07:45	37,317	22.31	34,446	19.01	34,446	19.01	34,446	19.01	34,446	19.01	28,705	13.20	37,317	22.31	28,705	13.20	147.04	1,640.00	1,787.04
07:45	08:00	37,317	22.31	34,446	19.01	34,446	19.01	34,446	19.01	34,446	19.01	28,705	13.20	37,317	22.31	28,705	13.20	147.04	1,640.00	1,787.04
08:00	08:15	37,317	22.31	34,446	19.01	34,446	19.01	34,446	19.01	34,446	19.01	28,705	13.20	37,317	22.31	28,705	13.20	147.04	1,640.00	1,787.04
08:15	08:30	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
08:30	08:45	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
08:45	09:00	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
09:00	09:15	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
09:15	09:30	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
09:30	09:45	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
09:45	10:00	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
10:00	10:15	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
10:15	10:30	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
10:30	10:45	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
10:45	11:00	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
11:00	11:15	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
11:15	11:30	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
11:30	11:45	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
11:45	12:00	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
12:00	12:15	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
12:15	12:30	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
12:30	12:45	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
12:45	13:00	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
13:00	13:15	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
13:15	13:30	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12

LOSSES ON THE TRANSFORMERS (DESIGN ALTERNATIVE -3) (in the first year)

Hour		TR-1		TR-2		TR-3		TR-4		TR-5		TR-6		TR-7		TR-8		Daily Load Losses (Wh)	Daily No-Load Losses (Wh)	Daily Total Losses (Wh)
from	to	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)	Load Duration Curve (W)	Losses (Wh)			
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R	S	T
			$B=5150x((A/0.9)/315000)^2x0.25$		$D=5150x((C/0.9)/315000)^2x0.25$		$F=5150x((E/0.9)/315000)^2x0.25$		$H=5150x((G/0.9)/315000)^2x0.25$		$J=5150x((I/0.9)/315000)^2x0.25$		$L=5150x((K/0.9)/315000)^2x0.25$		$N=5150x((M/0.9)/315000)^2x0.25$		$P=5150x((O/0.9)/315000)^2x0.25$	R=B+D+F+H+J+L+N+P	S=825x0.25X8	T=R+S
13:30	13:45	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
13:45	14:00	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
14:00	14:15	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
14:15	14:30	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
14:30	14:45	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
14:45	15:00	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
15:00	15:15	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
15:15	15:30	14,143	3.20	13,055	2.73	13,055	2.73	13,055	2.73	13,055	2.73	10,879	1.90	14,143	3.20	10,879	1.90	21.12	1,640.00	1,661.12
15:30	15:45	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
15:45	16:00	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
16:00	16:15	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
16:15	16:30	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
16:30	16:45	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
16:45	17:00	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
17:00	17:15	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
17:15	17:30	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
17:30	17:45	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
17:45	18:00	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
18:00	18:15	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
18:15	18:30	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
18:30	18:45	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
18:45	19:00	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
19:00	19:15	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
19:15	19:30	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
19:30	19:45	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
19:45	20:00	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
20:00	20:15	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
20:15	20:30	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
20:30	20:45	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
20:45	21:00	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
21:00	21:15	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
21:15	21:30	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
21:30	21:45	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
21:45	22:00	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
22:00	22:15	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
22:15	22:30	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
22:30	22:45	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
22:45	23:00	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
23:00	23:15	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
23:15	23:30	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
23:30	23:45	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
23:45	00:00	3,770	0.23	3,480	0.19	3,480	0.19	3,480	0.19	3,480	0.19	2,900	0.13	3,770	0.23	2,900	0.13	1.50	1,640.00	1,641.50
Total:		-	2,564.74	-	2,185.34	-	2,185.34	-	2,185.34	-	2,185.34	-	1,517.60	-	2,564.74	-	1,517.60	16,906.01	157,440.00	174,346.01

LOSSES IN 30 YEARS (DESIGN ALTERNATIVE - 1)

Year	Diversifed Demand		Annual	Annual Losses (kWh)										Cost of	PV of
	Div. Max. (VA)	Increase (%)	Consumption (kWh)	Metering Devices		Within Buildings	Between B & DB	Between DB & TR	Transformers		Total (kWh)	Loss Ratio (%)		Losses (YTL)	Cost (YTL)
				Voltage Crt.	Current Crt.				No-Load	Load					
	A	B	C	D	E	F	G	H	I	J	K	L		M	N
											K=D+E+F+ G+H+I+J	L=K/C		M=K x 0.161280	
1	1,000	0.00%	1,754,528	8,234	307	5,529	3,517	16,703	34,164	4,225	72,678	4.14%		11,722	11,722
2	1,293	29.29%	2,268,417	8,234	513	9,243	5,878	27,919	34,164	7,062	93,013	4.10%		15,001	13,637
3	1,500	16.02%	2,631,791	8,234	690	12,441	7,912	37,581	34,164	9,506	110,528	4.20%		17,826	14,732
4	1,646	9.76%	2,888,736	8,234	832	14,989	9,533	45,277	34,164	11,452	124,480	4.31%		20,076	15,084
5	1,750	6.29%	3,070,423	8,234	939	16,933	10,769	51,151	34,164	12,938	135,130	4.40%		21,794	14,885
6	1,823	4.18%	3,198,896	8,234	1,020	18,380	11,689	55,522	34,164	14,044	143,053	4.47%		23,072	14,326
7	1,875	2.84%	3,289,739	8,234	1,078	19,439	12,363	58,720	34,164	14,852	148,851	4.52%		24,007	13,551
8	1,912	1.95%	3,353,975	8,234	1,121	20,205	12,850	61,035	34,164	15,438	153,048	4.56%		24,684	12,667
9	1,937	1.35%	3,399,397	8,234	1,152	20,756	13,201	62,700	34,164	15,859	156,066	4.59%		25,170	11,742
10	1,956	0.94%	3,431,515	8,234	1,173	21,150	13,451	63,890	34,164	16,160	158,224	4.61%		25,518	10,822
11	1,969	0.66%	3,454,226	8,234	1,189	21,431	13,630	64,739	34,164	16,375	159,762	4.63%		25,766	9,934
12	1,978	0.46%	3,470,285	8,234	1,200	21,631	13,757	65,342	34,164	16,527	160,856	4.64%		25,943	9,093
13	1,984	0.33%	3,481,641	8,234	1,208	21,773	13,847	65,770	34,164	16,636	161,632	4.64%		26,068	8,306
14	1,989	0.23%	3,489,670	8,234	1,214	21,873	13,911	66,074	34,164	16,713	162,183	4.65%		26,157	7,577
15	1,992	0.16%	3,495,348	8,234	1,217	21,945	13,956	66,289	34,164	16,767	162,573	4.65%		26,220	6,904
16	1,994	0.11%	3,499,363	8,234	1,220	21,995	13,989	66,441	34,164	16,806	162,849	4.65%		26,264	6,287
17	1,996	0.08%	3,502,202	8,234	1,222	22,031	14,011	66,549	34,164	16,833	163,045	4.66%		26,296	5,723
18	1,997	0.06%	3,504,209	8,234	1,224	22,056	14,027	66,626	34,164	16,852	163,183	4.66%		26,318	5,207
19	1,998	0.04%	3,505,628	8,234	1,225	22,074	14,039	66,680	34,164	16,866	163,281	4.66%		26,334	4,736
20	1,999	0.03%	3,506,632	8,234	1,225	22,086	14,047	66,718	34,164	16,875	163,350	4.66%		26,345	4,308
21	1,999	0.02%	3,507,342	8,234	1,226	22,095	14,052	66,745	34,164	16,882	163,399	4.66%		26,353	3,917
22	1,999	0.01%	3,507,844	8,234	1,226	22,102	14,056	66,764	34,164	16,887	163,434	4.66%		26,359	3,562
23	2,000	0.01%	3,508,199	8,234	1,226	22,106	14,059	66,777	34,164	16,891	163,458	4.66%		26,363	3,239
24	2,000	0.01%	3,508,449	8,234	1,227	22,109	14,061	66,787	34,164	16,893	163,476	4.66%		26,365	2,944
25	2,000	0.01%	3,508,627	8,234	1,227	22,112	14,063	66,794	34,164	16,895	163,488	4.66%		26,367	2,677
26	2,000	0.00%	3,508,752	8,234	1,227	22,113	14,064	66,798	34,164	16,896	163,497	4.66%		26,369	2,434
27	2,000	0.00%	3,508,841	8,234	1,227	22,114	14,064	66,802	34,164	16,897	163,503	4.66%		26,370	2,213
28	2,000	0.00%	3,508,904	8,234	1,227	22,115	14,065	66,804	34,164	16,897	163,507	4.66%		26,370	2,011
29	2,000	0.00%	3,508,948	8,234	1,227	22,116	14,065	66,806	34,164	16,898	163,510	4.66%		26,371	1,829
30	2,000	0.00%	3,508,980	8,234	1,227	22,116	14,066	66,807	34,164	16,898	163,512	4.66%		26,371	1,662
		Total:	99,281,508	247,032	33,236	599,059	380,993	1,809,609	1,024,920	457,720	**4,552,569**	4.59%		734,238	**227,731**

LOSSES IN 30 YEARS (DESIGN ALTERNATIVE - 2)

Year	Diversifed Demand		Annual	Annual Losses (kWh)										Cost of	PV of
	Div. Max. (VA)	Increase (%)	Consumption (kWh)	Metering Devices Voltage Crt.	Metering Devices Current Crt.	Within Buildings	Between B & DB	Between DB & TR	Transformers No-Load	Transformers Load	Total (kWh)	Loss Ratio (%)		Losses (YTL)	Cost (YTL)
	A	B	C	D	E	F	G	H	I	J	K	L		M	N
											K=D+E+F+ G+H+I+J	L=K/C		M=K x 0.161280	
1	1,000	0.00%	1,754,528	8,234	307	5,529	3,517	18,232	47,304	4,696	87,819	5.01%		14,163	14,163
2	1,293	29.29%	2,268,417	8,234	513	9,243	5,878	30,476	47,304	7,850	109,498	4.83%		17,660	16,054
3	1,500	16.02%	2,631,791	8,234	690	12,441	7,912	41,022	47,304	10,566	128,170	4.87%		20,671	17,084
4	1,646	9.76%	2,888,736	8,234	832	14,989	9,533	49,423	47,304	12,730	143,044	4.95%		23,070	17,333
5	1,750	6.29%	3,070,423	8,234	939	16,933	10,769	55,835	47,304	14,381	154,397	5.03%		24,901	17,008
6	1,823	4.18%	3,198,896	8,234	1,020	18,380	11,689	60,606	47,304	15,610	162,843	5.09%		26,263	16,307
7	1,875	2.84%	3,289,739	8,234	1,078	19,439	12,363	64,097	47,304	16,509	169,025	5.14%		27,260	15,388
8	1,912	1.95%	3,353,975	8,234	1,121	20,205	12,850	66,624	47,304	17,160	173,500	5.17%		27,982	14,359
9	1,937	1.35%	3,399,397	8,234	1,152	20,756	13,201	68,441	47,304	17,628	176,716	5.20%		28,501	13,296
10	1,956	0.94%	3,431,515	8,234	1,173	21,150	13,451	69,741	47,304	17,963	179,017	5.22%		28,872	12,244
11	1,969	0.66%	3,454,226	8,234	1,189	21,431	13,630	70,667	47,304	18,201	180,657	5.23%		29,136	11,233
12	1,978	0.46%	3,470,285	8,234	1,200	21,631	13,757	71,325	47,304	18,371	181,823	5.24%		29,324	10,278
13	1,984	0.33%	3,481,641	8,234	1,208	21,773	13,847	71,793	47,304	18,492	182,651	5.25%		29,458	9,386
14	1,989	0.23%	3,489,670	8,234	1,214	21,873	13,911	72,124	47,304	18,577	183,238	5.25%		29,553	8,560
15	1,992	0.16%	3,495,348	8,234	1,217	21,945	13,956	72,359	47,304	18,637	183,654	5.25%		29,620	7,800
16	1,994	0.11%	3,499,363	8,234	1,220	21,995	13,989	72,526	47,304	18,680	183,948	5.26%		29,667	7,102
17	1,996	0.08%	3,502,202	8,234	1,222	22,031	14,011	72,643	47,304	18,711	184,157	5.26%		29,701	6,464
18	1,997	0.06%	3,504,209	8,234	1,224	22,056	14,027	72,727	47,304	18,732	184,304	5.26%		29,725	5,881
19	1,998	0.04%	3,505,628	8,234	1,225	22,074	14,039	72,786	47,304	18,747	184,408	5.26%		29,741	5,349
20	1,999	0.03%	3,506,632	8,234	1,225	22,086	14,047	72,827	47,304	18,758	184,482	5.26%		29,753	4,865
21	1,999	0.02%	3,507,342	8,234	1,226	22,095	14,052	72,857	47,304	18,766	184,534	5.26%		29,762	4,424
22	1,999	0.01%	3,507,844	8,234	1,226	22,102	14,056	72,878	47,304	18,771	184,571	5.26%		29,768	4,023
23	2,000	0.01%	3,508,199	8,234	1,226	22,106	14,059	72,892	47,304	18,775	184,597	5.26%		29,772	3,657
24	2,000	0.01%	3,508,449	8,234	1,227	22,109	14,061	72,903	47,304	18,777	184,616	5.26%		29,775	3,325
25	2,000	0.01%	3,508,627	8,234	1,227	22,112	14,063	72,910	47,304	18,779	184,629	5.26%		29,777	3,023
26	2,000	0.00%	3,508,752	8,234	1,227	22,113	14,064	72,915	47,304	18,781	184,638	5.26%		29,778	2,748
27	2,000	0.00%	3,508,841	8,234	1,227	22,114	14,064	72,919	47,304	18,782	184,645	5.26%		29,779	2,499
28	2,000	0.00%	3,508,904	8,234	1,227	22,115	14,065	72,922	47,304	18,782	184,649	5.26%		29,780	2,272
29	2,000	0.00%	3,508,948	8,234	1,227	22,116	14,065	72,924	47,304	18,783	184,653	5.26%		29,781	2,065
30	2,000	0.00%	3,508,980	8,234	1,227	22,116	14,066	72,925	47,304	18,783	184,655	5.26%		29,781	1,877
		Total:	99,281,508	247,032	33,236	599,059	380,993	1,975,319	1,419,120	508,778	**5,163,537**	5.20%		832,775	**260,069**

LOSSES IN 30 YEARS (DESIGN ALTERNATIVE - 3)

Year	Diversifed Demand		Annual	Annual Losses (kWh)										Cost of	PV of
	Div. Max. (VA)	Increase (%)	Consumption (kWh)	Metering Devices Voltage Crt.	Metering Devices Current Crt.	Within Buildings	Between B & DB	Between DB & TR	Transformers No-Load	Transformers Load	Total (kWh)	Loss Ratio (%)	Losses (YTL)	Cost (YTL)
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
											K=D+E+F+G+H+I+J	L=K/C	M=K x 0.161280	
1	1,000	0.00%	1,754,528	8,234	307	5,529	3,517	16,710	57,466	6,171	97,933	5.58%	15,795	15,795
2	1,293	29.29%	2,268,417	8,234	513	9,243	5,878	27,932	57,466	10,315	119,580	5.27%	19,286	17,533
3	1,500	16.02%	2,631,791	8,234	690	12,441	7,912	37,597	57,466	13,884	138,224	5.25%	22,293	18,424
4	1,646	9.76%	2,888,736	8,234	832	14,989	9,533	45,297	57,466	16,727	153,077	5.30%	24,688	18,549
5	1,750	6.29%	3,070,423	8,234	939	16,933	10,769	51,174	57,466	18,898	164,414	5.35%	26,517	18,111
6	1,823	4.18%	3,198,896	8,234	1,020	18,380	11,689	55,546	57,466	20,512	172,847	5.40%	27,877	17,309
7	1,875	2.84%	3,289,739	8,234	1,078	19,439	12,363	58,746	57,466	21,694	179,019	5.44%	28,872	16,298
8	1,912	1.95%	3,353,975	8,234	1,121	20,205	12,850	61,062	57,466	22,549	183,488	5.47%	29,593	15,186
9	1,937	1.35%	3,399,397	8,234	1,152	20,756	13,201	62,727	57,466	23,164	186,700	5.49%	30,111	14,047
10	1,956	0.94%	3,431,515	8,234	1,173	21,150	13,451	63,918	57,466	23,604	188,997	5.51%	30,481	12,927
11	1,969	0.66%	3,454,226	8,234	1,189	21,431	13,630	64,767	57,466	23,917	190,635	5.52%	30,746	11,854
12	1,978	0.46%	3,470,285	8,234	1,200	21,631	13,757	65,371	57,466	24,140	191,799	5.53%	30,933	10,842
13	1,984	0.33%	3,481,641	8,234	1,208	21,773	13,847	65,799	57,466	24,299	192,626	5.53%	31,067	9,899
14	1,989	0.23%	3,489,670	8,234	1,214	21,873	13,911	66,103	57,466	24,411	193,212	5.54%	31,161	9,026
15	1,992	0.16%	3,495,348	8,234	1,217	21,945	13,956	66,318	57,466	24,490	193,627	5.54%	31,228	8,223
16	1,994	0.11%	3,499,363	8,234	1,220	21,995	13,989	66,471	57,466	24,547	193,921	5.54%	31,276	7,487
17	1,996	0.08%	3,502,202	8,234	1,222	22,031	14,011	66,579	57,466	24,586	194,129	5.54%	31,309	6,814
18	1,997	0.06%	3,504,209	8,234	1,224	22,056	14,027	66,655	57,466	24,615	194,276	5.54%	31,333	6,199
19	1,998	0.04%	3,505,628	8,234	1,225	22,074	14,039	66,709	57,466	24,635	194,381	5.54%	31,350	5,639
20	1,999	0.03%	3,506,632	8,234	1,225	22,086	14,047	66,747	57,466	24,649	194,454	5.55%	31,362	5,128
21	1,999	0.02%	3,507,342	8,234	1,226	22,095	14,052	66,774	57,466	24,659	194,506	5.55%	31,370	4,663
22	1,999	0.01%	3,507,844	8,234	1,226	22,102	14,056	66,793	57,466	24,666	194,543	5.55%	31,376	4,240
23	2,000	0.01%	3,508,199	8,234	1,226	22,106	14,059	66,807	57,466	24,671	194,569	5.55%	31,380	3,855
24	2,000	0.01%	3,508,449	8,234	1,227	22,109	14,061	66,816	57,466	24,674	194,588	5.55%	31,383	3,505
25	2,000	0.01%	3,508,627	8,234	1,227	22,112	14,063	66,823	57,466	24,677	194,601	5.55%	31,385	3,186
26	2,000	0.00%	3,508,752	8,234	1,227	22,113	14,064	66,828	57,466	24,679	194,610	5.55%	31,387	2,897
27	2,000	0.00%	3,508,841	8,234	1,227	22,114	14,064	66,831	57,466	24,680	194,617	5.55%	31,388	2,634
28	2,000	0.00%	3,508,904	8,234	1,227	22,115	14,065	66,834	57,466	24,681	194,621	5.55%	31,389	2,394
29	2,000	0.00%	3,508,948	8,234	1,227	22,116	14,065	66,835	57,466	24,681	194,624	5.55%	31,389	2,177
30	2,000	0.00%	3,508,980	8,234	1,227	22,116	14,066	66,836	57,466	24,682	194,627	5.55%	31,389	1,979
		Total:	99,281,508	247,032	33,236	599,059	380,993	1,810,403	1,723,968	668,555	**5,463,246**	5.50%	881,112	**276,817**

LOSSES ON MEDIUM VOLTAGE LEVEL

34.5 / 0.4 kV	Distribution TRs		Cable		Number of TR	Distance between TRs (m)	Cable Losses			34.5/10.5 kV TR Losses		Total Losses (Wh)	Total Energy (Wh)	Loss Ratio (%)
	Rating (kVA)	Voltage (kV)	Cross-Section	Resistance (ohm/m)			R (ohm)	Sum of I^2	Losses (Wh)	No-Load	Load			
Design Alternative - 1	1,250	34.5	(3 x 95) mm2	0.000232	9	500	0.1160	933,502	81,215	-	-	81,215	46,023,750	0.18%
Design Alternative - 2	630	34.5	(3 x 95) mm2	0.000232	18	250	0.0580	1,754,721	76,330	-	-	76,330	46,391,940	0.16%
Design Alternative - 3	315	34.5	(3 x 95) mm2	0.000232	36	125	0.0290	3,370,911	73,317	-	-	73,317	46,391,940	0.16%

34.5 / 10.5 / 0.4 kV	Distribution TRs		Cable		Number of TR	Distance between TRs (m)	Cable Losses			34.5/10.5 kV TR Losses		Total Losses (Wh)	Total Energy (Wh)	Loss Ratio (%)
	Rating (kVA)	Voltage (kV)	Cross-Section	Resistance (ohm/m)			R (ohm)	Sum of I^2	Losses (Wh)	No-Load	Load			
Design Alternative - 1	1,250	10.5	(3 x 95) mm2	0.000232	3	500	0.1160	495,060	43,070	134,400	32,072	209,542	15,341,250	1.37%
Design Alternative - 2	630	10.5	(3 x 95) mm2	0.000232	6	250	0.0580	817,396	35,557	134,400	32,587	202,544	15,463,980	1.31%
Design Alternative - 3	315	10.5	(3 x 95) mm2	0.000232	12	125	0.0290	1,459,636	31,747	134,400	32,587	198,734	15,463,980	1.29%

SUMMARY TABLE OF LOSS CALCULATIONS (EFFECT OF POWER FACTOR - INCREASED FROM 0.9 TO 1.0)

Losses (kWh)		In 1st Year						In 20th Year						During 30 Years					
		Design Alt - 1		Design Alt - 2		Design Alt - 3		Design Alt - 1		Design Alt - 2		Design Alt - 3		Design Alt - 1		Design Alt - 2		Design Alt - 3	
Meters	voltage cct	8,234	97.07%	8,234	97.07%	8,234	97.07%	8,234	89.24%	8,234	89.24%	8,234	89.24%	247,032	90.17%	247,032	90.17%	247,032	90.17%
	current cct	248	2.93%	248	2.93%	248	2.93%	993	10.76%	993	10.76%	993	10.76%	26,921	9.83%	26,921	9.83%	26,921	9.83%
	total	8,483	100%	8,483	100%	8,483	100%	9,227	100%	9,227	100%	9,227	100%	273,953	100%	273,953	100%	273,953	100%
Cables	within building	4,479	21.47%	4,479	20.27%	4,479	21.47%	17,890	21.47%	17,890	20.27%	17,890	21.47%	485,238	21.47%	485,238	20.27%	485,238	21.47%
	between B&DB	2,848	13.66%	2,848	12.89%	2,848	13.65%	11,378	13.66%	11,378	12.89%	11,378	13.65%	308,605	13.66%	308,605	12.89%	308,605	13.65%
	between DB&TR	13,529	64.87%	14,768	66.84%	13,535	64.88%	54,041	64.87%	58,990	66.84%	54,065	64.88%	1,465,783	64.87%	1,600,009	66.84%	1,466,427	64.88%
	total	20,856	100%	22,095	100%	20,862	100%	83,309	100%	88,258	100%	83,333	100%	2,259,626	100%	2,393,851	100%	2,260,269	100%
TRs	no-load	34,164	90.90%	47,304	92.56%	57,466	92.00%	34,164	71.42%	47,304	75.69%	57,466	74.22%	1,024,920	73.44%	1,419,120	77.50%	1,723,968	76.10%
	load	3,422	9.10%	3,804	7.44%	4,998	8.00%	13,669	28.58%	15,194	24.31%	19,965	25.78%	370,753	26.56%	412,110	22.50%	541,530	23.90%
	total	37,586	100%	51,108	100%	62,464	100%	47,833	100%	62,498	100%	77,431	100%	1,395,673	100%	1,831,230	100%	2,265,498	100%
Total	meters	8,483	12.68%	8,483	10.38%	8,483	9.24%	9,227	6.57%	9,227	5.77%	9,227	5.43%	273,953	6.97%	273,953	6.09%	273,953	5.71%
	cables	20,856	31.16%	22,095	27.05%	20,862	22.72%	83,309	59.35%	88,258	55.17%	83,333	49.02%	2,259,626	57.51%	2,393,851	53.21%	2,260,269	47.09%
	TRs	37,586	56.16%	51,108	62.57%	62,464	68.04%	47,833	34.08%	62,498	39.07%	77,431	45.55%	1,395,673	35.52%	1,831,230	40.70%	2,265,498	47.20%
	total	66,925	100%	81,686	100%	91,809	100%	140,369	100%	159,983	100%	169,991	100%	3,929,251	100%	4,499,034	100%	4,799,720	100%
Total	no-load	42,398	63.35%	55,538	67.99%	65,700	71.56%	42,398	30.20%	55,538	34.72%	65,700	38.65%	1,271,952	32.37%	1,666,152	37.03%	1,971,000	41.06%
	load	24,527	36.65%	26,147	32.01%	26,109	28.44%	97,971	69.80%	104,444	65.28%	104,291	61.35%	2,657,299	67.63%	2,832,882	62.97%	2,828,720	58.94%
	total	66,925	100%	81,686	100%	91,809	100%	140,369	100%	159,983	100%	169,991	100%	3,929,251	100%	4,499,034	100%	4,799,720	100%
Consumption(kWh)		1,754,528		1,754,528		1,754,528		3,506,632		3,506,632		3,506,632		99,281,508		99,281,508		99,281,508	
Loss Ratio (%)		**3.81%**		**4.66%**		**5.23%**		**4.00%**		**4.56%**		**4.85%**		**3.96%**		**4.53%**		**4.83%**	
Cost of Losses (YTL)		10,794		13,174		14,807		22,639		25,802		27,416		633,710		725,604		774,099	
PV of Cost (YTL)		10,794		13,174		14,807		3,702		4,219		4,483		197,935		228,303		245,099	
Base Case Loss Ratio (%)		*4.14%*		*5.01%*		*5.58%*		*4.66%*		*5.26%*		*5.55%*		*4.59%*		*5.20%*		*5.50%*	
Change in Losses (%)		***-7.92%***		***-6.98%***		***-6.25%***		***-14.07%***		***-13.28%***		***-12.58%***		***-13.69%***		***-12.87%***		***-12.15%***	

SUMMARY TABLE OF LOSS CALCULATIONS (EFFECT OF LOAD CURVE PEAK VALUE - MAX LOAD LIMITED AT 1,000 W)

Losses (kWh)		In 1st Year						In 20th Year						During 30 Years					
		Design Alt - 1		Design Alt - 2		Design Alt - 3		Design Alt - 1		Design Alt - 2		Design Alt - 3		Design Alt - 1		Design Alt - 2		Design Alt - 3	
Meters	voltage cct	8,234	97.21%	8,234	97.21%	8,234	97.21%	8,234	89.71%	8,234	89.71%	8,234	89.71%	247,032	90.61%	247,032	90.61%	247,032	90.61%
	current cct	236	2.79%	236	2.79%	236	2.79%	944	10.29%	944	10.29%	944	10.29%	25,612	9.39%	25,612	9.39%	25,612	9.39%
	total	8,471	100%	8,471	100%	8,471	100%	9,179	100%	9,179	100%	9,179	100%	272,644	100%	272,644	100%	272,644	100%
Cables	within building	4,261	17.84%	4,261	16.80%	4,261	17.88%	17,020	17.84%	17,020	16.80%	17,020	17.88%	461,645	17.84%	461,645	16.80%	461,645	17.88%
	between B&DB	3,247	13.60%	3,247	12.81%	3,247	13.63%	12,971	13.60%	12,971	12.81%	12,971	13.63%	351,822	13.60%	351,822	12.81%	351,822	13.63%
	between DB&TR	16,372	68.56%	17,847	70.39%	16,323	68.49%	65,396	68.56%	71,290	70.39%	65,200	68.49%	1,773,751	68.56%	1,933,626	70.39%	1,768,442	68.49%
	total	23,880	100%	25,355	100%	23,831	100%	95,387	100%	101,282	100%	95,191	100%	2,587,218	100%	2,747,093	100%	2,581,910	100%
TRs	no-load	34,164	89.18%	47,304	91.12%	57,466	90.46%	34,164	67.35%	47,304	71.98%	57,466	70.37%	1,024,920	69.52%	1,419,120	73.97%	1,723,968	72.43%
	load	4,147	10.82%	4,610	8.88%	6,057	9.54%	16,565	32.65%	18,413	28.02%	24,196	29.63%	449,310	30.48%	499,430	26.03%	656,272	27.57%
	total	38,311	100%	51,914	100%	63,523	100%	50,729	100%	65,717	100%	81,661	100%	1,474,230	100%	1,918,550	100%	2,380,240	100%
Total	meters	8,471	11.99%	8,471	9.88%	8,471	8.84%	9,179	5.91%	9,179	5.21%	9,179	4.93%	272,644	6.29%	272,644	5.52%	272,644	5.21%
	cables	23,880	33.79%	25,355	29.57%	23,831	24.87%	95,387	61.42%	101,282	57.49%	95,191	51.17%	2,587,218	59.69%	2,747,093	55.63%	2,581,910	49.32%
	TRs	38,311	54.22%	51,914	60.55%	63,523	66.29%	50,729	32.67%	65,717	37.30%	81,661	43.90%	1,474,230	34.01%	1,918,550	38.85%	2,380,240	45.47%
	total	70,662	100%	85,740	100%	95,824	100%	155,295	100%	176,178	100%	186,032	100%	4,334,092	100%	4,938,287	100%	5,234,793	100%
Total	no-load	42,398	60.00%	55,538	64.78%	65,700	68.56%	42,398	27.30%	55,538	31.52%	65,700	35.32%	1,271,952	29.35%	1,666,152	33.74%	1,971,000	37.65%
	load	28,263	40.00%	30,201	35.22%	30,124	31.44%	112,897	72.70%	120,639	68.48%	120,332	64.68%	3,062,140	70.65%	3,272,135	66.26%	3,263,793	62.35%
	total	70,662	100%	85,740	100%	95,824	100%	155,295	100%	176,178	100%	186,032	100%	4,334,092	100%	4,938,287	100%	5,234,793	100%
Consumption(kWh)		1,754,528		1,754,528		1,754,528		3,506,632		3,506,632		3,506,632		99,281,508		99,281,508		99,281,508	
Loss Ratio (%)		**4.03%**		**4.89%**		**5.46%**		**4.43%**		**5.02%**		**5.31%**		**4.37%**		**4.97%**		**5.27%**	
Cost of Losses (YTL)		11,396		13,828		15,455		25,046		28,414		30,003		699,002		796,447		844,267	
PV of Cost (YTL)		11,396		13,828		15,455		4,095		4,646		4,906		217,287		249,301		265,897	
Base Case Loss Ratio (%)		*4.14%*		*5.01%*		*5.58%*		*4.66%*		*5.26%*		*5.55%*		*4.59%*		*5.20%*		*5.50%*	
Change in Losses (%)		***-2.77%***		***-2.37%***		***-2.15%***		***-4.93%***		***-4.50%***		***-4.33%***		***-4.80%***		***-4.36%***		***-4.18%***	

SUMMARY TABLE OF LOSS CALCULATIONS (EFFECT OF LOAD CURVE PEAK DURATION - INCREASED FROM 15 MIN TO 30 MIN)

Losses (kWh)		In 1st Year						In 20th Year						During 30 Years					
		Design Alt - 1		Design Alt - 2		Design Alt - 3		Design Alt - 1		Design Alt - 2		Design Alt - 3		Design Alt - 1		Design Alt - 2		Design Alt - 3	
Meters	voltage cct	8,234	95.84%	8,234	95.84%	8,234	95.84%	8,234	85.21%	8,234	85.21%	8,234	85.21%	247,032	86.43%	247,032	86.43%	247,032	86.43%
	current cct	358	4.16%	358	4.16%	358	4.16%	1,429	14.79%	1,429	14.79%	1,429	14.79%	38,772	13.57%	38,772	13.57%	38,772	13.57%
	total	8,592	100%	8,592	100%	8,592	100%	9,664	100%	9,664	100%	9,664	100%	285,804	100%	285,804	100%	285,804	100%
Cables	within building	6,450	24.19%	6,450	22.87%	6,450	24.18%	25,766	24.19%	25,766	22.87%	25,766	24.18%	698,848	24.19%	698,848	22.87%	698,848	24.18%
	between B&DB	3,517	13.19%	3,517	12.47%	3,517	13.18%	14,047	13.19%	14,047	12.47%	14,047	13.18%	380,993	13.19%	380,993	12.47%	380,993	13.18%
	between DB&TR	16,703	62.63%	18,232	64.66%	16,710	62.64%	66,718	62.63%	72,827	64.66%	66,747	62.64%	1,809,609	62.63%	1,975,319	64.66%	1,810,403	62.64%
	total	26,669	100%	28,199	100%	26,677	100%	106,530	100%	112,640	100%	106,559	100%	2,889,450	100%	3,055,160	100%	2,890,244	100%
TRs	no-load	34,164	88.99%	47,304	90.97%	57,466	90.30%	34,164	66.94%	47,304	71.61%	57,466	69.98%	1,024,920	69.13%	1,419,120	73.61%	1,723,968	72.06%
	load	4,225	11.01%	4,696	9.03%	6,171	9.70%	16,875	33.06%	18,758	28.39%	24,649	30.02%	457,720	30.87%	508,778	26.39%	668,555	27.94%
	total	38,389	100%	52,000	100%	63,636	100%	51,039	100%	66,062	100%	82,114	100%	1,482,640	100%	1,927,898	100%	2,392,523	100%
Total	meters	8,592	11.67%	8,592	9.68%	8,592	8.69%	9,664	5.78%	9,664	5.13%	9,664	4.87%	285,804	6.14%	285,804	5.42%	285,804	5.13%
	cables	26,669	36.21%	28,199	31.76%	26,677	26.97%	106,530	63.70%	112,640	59.80%	106,559	53.73%	2,889,450	62.03%	3,055,160	57.99%	2,890,244	51.90%
	TRs	38,389	52.12%	52,000	58.56%	63,636	64.34%	51,039	30.52%	66,062	35.07%	82,114	41.40%	1,482,640	31.83%	1,927,898	36.59%	2,392,523	42.96%
	total	73,650	100%	88,791	100%	98,905	100%	167,233	100%	188,365	100%	198,337	100%	4,657,894	100%	5,268,863	100%	5,568,572	100%
Total	no-load	42,398	57.57%	55,538	62.55%	65,700	66.43%	42,398	25.35%	55,538	29.48%	65,700	33.13%	1,271,952	27.31%	1,666,152	31.62%	1,971,000	35.40%
	load	31,252	42.43%	33,253	37.45%	33,205	33.57%	124,835	74.65%	132,827	70.52%	132,637	66.87%	3,385,942	72.69%	3,602,711	68.38%	3,597,572	64.60%
	total	73,650	100%	88,791	100%	98,905	100%	167,233	100%	188,365	100%	198,337	100%	4,657,894	100%	5,268,863	100%	5,568,572	100%
Consumption(kWh)		1,754,528		1,754,528		1,754,528		3,506,632		3,506,632		3,506,632		99,281,508		99,281,508		99,281,508	
Loss Ratio (%)		**4.20%**		**5.06%**		**5.64%**		**4.77%**		**5.37%**		**5.66%**		**4.69%**		**5.31%**		**5.61%**	
Cost of Losses (YTL)		11,878		14,320		15,951		26,971		30,380		31,988		751,225		849,762		898,099	
PV of Cost (YTL)		11,878		14,320		15,951		4,410		4,967		5,230		232,766		265,104		281,852	
Base Case Loss Ratio (%)		*4.14%*		*5.01%*		*5.58%*		*4.66%*		*5.26%*		*5.55%*		*4.59%*		*5.20%*		*5.50%*	
Change in Losses (%)		***1.34%***		***1.11%***		***0.99%***		***2.38%***		***2.10%***		***2.00%***		***2.31%***		***2.04%***		***1.93%***	

SUMMARY TABLE OF LOSS CALCULATIONS (EFFECT OF LOAD CURVE PEAK DURATION - INCREASED FROM 15 MIN TO 45 MIN)

Losses (kWh)		In 1st Year						In 20th Year						During 30 Years					
		Design Alt - 1		Design Alt - 2		Design Alt - 3		Design Alt - 1		Design Alt - 2		Design Alt - 3		Design Alt - 1		Design Alt - 2		Design Alt - 3	
Meters	voltage cct	8,234	95.14%	8,234	95.14%	8,234	95.14%	8,234	83.06%	8,234	83.06%	8,234	83.06%	247,032	84.43%	247,032	84.43%	247,032	84.43%
	current cct	421	4.86%	421	4.86%	421	4.86%	1,680	16.94%	1,680	16.94%	1,680	16.94%	45,566	15.57%	45,566	15.57%	45,566	15.57%
	total	8,655	100%	8,655	100%	8,655	100%	9,914	100%	9,914	100%	9,914	100%	292,598	100%	292,598	100%	292,598	100%
Cables	within building	7,581	26.28%	7,581	24.89%	7,581	26.28%	30,280	26.28%	30,280	24.89%	30,280	26.28%	821,305	26.28%	821,305	24.89%	821,305	26.28%
	between B&DB	3,679	12.75%	3,679	12.08%	3,679	12.75%	14,697	12.75%	14,697	12.08%	14,697	12.75%	398,623	12.75%	398,623	12.08%	398,623	12.75%
	between DB&TR	17,589	60.97%	19,196	63.03%	17,588	60.97%	70,257	60.97%	76,678	63.03%	70,256	60.97%	1,905,604	60.97%	2,079,750	63.03%	1,905,575	60.97%
	total	28,848	100%	30,456	100%	28,848	100%	115,234	100%	121,655	100%	115,233	100%	3,125,532	100%	3,299,677	100%	3,125,503	100%
TRs	no-load	34,164	88.48%	47,304	90.53%	57,466	89.84%	34,164	65.78%	47,304	70.54%	57,466	68.88%	1,024,920	68.01%	1,419,120	72.59%	1,723,968	71.00%
	load	4,450	11.52%	4,946	9.47%	6,499	10.16%	17,774	34.22%	19,757	29.46%	25,961	31.12%	482,093	31.99%	535,870	27.41%	704,155	29.00%
	total	38,614	100%	52,250	100%	63,965	100%	51,938	100%	67,061	100%	83,427	100%	1,507,013	100%	1,954,990	100%	2,428,123	100%
Total	meters	8,655	11.37%	8,655	9.47%	8,655	8.53%	9,914	5.60%	9,914	4.99%	9,914	4.75%	292,598	5.94%	292,598	5.27%	292,598	5.00%
	cables	28,848	37.90%	30,456	33.34%	28,848	28.43%	115,234	65.07%	121,655	61.25%	115,233	55.25%	3,125,532	63.46%	3,299,677	59.48%	3,125,503	53.46%
	TRs	38,614	50.73%	52,250	57.19%	63,965	63.04%	51,938	29.33%	67,061	33.76%	83,427	40.00%	1,507,013	30.60%	1,954,990	35.24%	2,428,123	41.53%
	total	76,117	100%	91,361	100%	101,468	100%	177,086	100%	198,630	100%	208,574	100%	4,925,143	100%	5,547,266	100%	5,846,224	100%
Total	no-load	42,398	55.70%	55,538	60.79%	65,700	64.75%	42,398	23.94%	55,538	27.96%	65,700	31.50%	1,271,952	25.83%	1,666,152	30.04%	1,971,000	33.71%
	load	33,719	44.30%	35,822	39.21%	35,768	35.25%	134,688	76.06%	143,091	72.04%	142,874	68.50%	3,653,191	74.17%	3,881,114	69.96%	3,875,224	66.29%
	total	76,117	100%	91,361	100%	101,468	100%	177,086	100%	198,630	100%	208,574	100%	4,925,143	100%	5,547,266	100%	5,846,224	100%
Consumption(kWh)		1,754,528		1,754,528		1,754,528		3,506,632		3,506,632		3,506,632		99,281,508		99,281,508		99,281,508	
Loss Ratio (%)		**4.34%**		**5.21%**		**5.78%**		**5.05%**		**5.66%**		**5.95%**		**4.96%**		**5.59%**		**5.89%**	
Cost of Losses (YTL)		12,276		14,735		16,365		28,561		32,035		33,639		794,327		894,663		942,879	
PV of Cost (YTL)		12,276		14,735		16,365		4,670		5,238		5,500		245,541		278,412		295,125	
Base Case Loss Ratio (%)		*4.14%*		*5.01%*		*5.58%*		*4.66%*		*5.26%*		*5.55%*		*4.59%*		*5.20%*		*5.50%*	
Change in Losses (%)		***4.73%***		***4.03%***		***3.61%***		***8.41%***		***7.67%***		***7.26%***		***8.18%***		***7.43%***		***7.01%***	

SUMMARY TABLE OF LOSS CALCULATIONS (EFFECT OF LOAD CURVE PEAK DURATION - INCREASED FROM 15 MIN TO 60 MIN)

Losses (kWh)		In 1st Year						In 20th Year						During 30 Years					
		Design Alt - 1		Design Alt - 2		Design Alt - 3		Design Alt - 1		Design Alt - 2		Design Alt - 3		Design Alt - 1		Design Alt - 2		Design Alt - 3	
Meters	voltage cct	8,234	94.37%	8,234	94.37%	8,234	94.37%	8,234	80.75%	8,234	80.75%	8,234	80.75%	247,032	82.27%	247,032	82.27%	247,032	82.27%
	current cct	492	5.63%	492	5.63%	492	5.63%	1,963	19.25%	1,963	19.25%	1,963	19.25%	53,254	17.73%	53,254	17.73%	53,254	17.73%
	total	8,726	100%	8,726	100%	8,726	100%	10,198	100%	10,198	100%	10,198	100%	300,286	100%	300,286	100%	300,286	100%
Cables	within building	8,860	27.09%	8,860	25.67%	8,860	27.10%	35,389	27.09%	35,389	25.67%	35,389	27.10%	959,876	27.09%	959,876	25.67%	959,876	27.10%
	between B&DB	4,085	12.49%	4,085	11.84%	4,085	12.50%	16,319	12.49%	16,319	11.84%	16,319	12.50%	442,635	12.49%	442,635	11.84%	442,635	12.50%
	between DB&TR	19,763	60.42%	21,562	62.49%	19,747	60.40%	78,942	60.42%	86,131	62.49%	78,878	60.40%	2,141,182	60.42%	2,336,151	62.49%	2,139,437	60.40%
	total	32,708	100%	34,507	100%	32,692	100%	130,651	100%	137,839	100%	130,587	100%	3,543,693	100%	3,738,663	100%	3,541,949	100%
TRs	no-load	34,164	87.23%	47,304	89.48%	57,466	88.72%	34,164	63.10%	47,304	68.05%	57,466	66.32%	1,024,920	65.42%	1,419,120	70.20%	1,723,968	68.54%
	load	5,001	12.77%	5,559	10.52%	7,305	11.28%	19,978	36.90%	22,207	31.95%	29,181	33.68%	541,874	34.58%	602,320	29.80%	791,473	31.46%
	total	39,165	100%	52,863	100%	64,771	100%	54,142	100%	69,511	100%	86,646	100%	1,566,794	100%	2,021,440	100%	2,515,441	100%
Total	meters	8,726	10.83%	8,726	9.08%	8,726	8.22%	10,198	5.23%	10,198	4.69%	10,198	4.48%	300,286	5.55%	300,286	4.95%	300,286	4.72%
	cables	32,708	40.58%	34,507	35.91%	32,692	30.79%	130,651	67.00%	137,839	63.36%	130,587	57.42%	3,543,693	65.49%	3,738,663	61.69%	3,541,949	55.71%
	TRs	39,165	48.59%	52,863	55.01%	64,771	61.00%	54,142	27.77%	69,511	31.95%	86,646	38.10%	1,566,794	28.96%	2,021,440	33.35%	2,515,441	39.57%
	total	80,599	100%	96,097	100%	106,189	100%	194,991	100%	217,548	100%	227,431	100%	5,410,774	100%	6,060,389	100%	6,357,676	100%
Total	no-load	42,398	52.60%	55,538	57.79%	65,700	61.87%	42,398	21.74%	55,538	25.53%	65,700	28.89%	1,271,952	23.51%	1,666,152	27.49%	1,971,000	31.00%
	load	38,201	47.40%	40,558	42.21%	40,489	38.13%	152,593	78.26%	162,009	74.47%	161,731	71.11%	4,138,822	76.49%	4,394,237	72.51%	4,386,676	69.00%
	total	80,599	100%	96,097	100%	106,189	100%	194,991	100%	217,548	100%	227,431	100%	5,410,774	100%	6,060,389	100%	6,357,676	100%
Consumption(kWh)		1,754,528		1,754,528		1,754,528		3,506,632		3,506,632		3,506,632		99,281,508		99,281,508		99,281,508	
Loss Ratio (%)		**4.59%**		**5.48%**		**6.05%**		**5.56%**		**6.20%**		**6.49%**		**5.45%**		**6.10%**		**6.40%**	
Cost of Losses (YTL)		12,999		15,498		17,126		31,448		35,086		36,680		872,650		977,420		1,025,366	
PV of Cost (YTL)		12,999		15,498		17,126		5,142		5,737		5,997		268,756		302,941		319,574	
Base Case Loss Ratio (%)		*4.14%*		*5.01%*		*5.58%*		*4.66%*		*5.26%*		*5.55%*		*4.59%*		*5.20%*		*5.50%*	
Change in Losses (%)		***10.90%***		***9.43%***		***8.43%***		***19.37%***		***17.92%***		***16.96%***		***18.85%***		***17.37%***		***16.37%***	

SUMMARY TABLE OF LOSS CALCULATIONS (EFFECT OF VOLTAGE DROP)

		Situation 1	Situation 2	Situation 3
Max. Demand of a Consumer (VA)		2,500	5,000	5,000
Diversified Demand of the District (kVA)		940	1,880	1,880
Transformers (kVA)		500	500	1,000
Transformer Capacity (kVA)		1,000	1,000	2,000
Transformer Loading (%)		94%	188%	94%
Maximum Voltage Drop (%)		5.00%	10.00%	10.00%
Daily Total Consumption (Wh)		4,806,925	9,613,850	9,613,850
Between TR and DB	Losses (Wh)	105,686	439,959	439,959
	Ratio (%)	2.20%	4.58%	4.58%
Transformer No-Load	Losses (Wh)	60,000	60,000	76,800
	Ratio (%)	1.25%	0.62%	0.80%
Transformer Load	Losses (Wh)	34,879	139,514	63,040
	Ratio (%)	0.73%	1.45%	0.66%
Total	Losses (Wh)	200,565	639,473	579,799
	Ratio (%)	4.17%	6.65%	6.03%