A PROJECT REPORT

ON

POWER CONSUMPTION AND LOAD FORECASTING OF NIAMEY (NIGER REPUBLIC)

BY

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A PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING (B. ENG.) DEGREE, IN THE DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING TECHNOLOGY

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA.

DECEMBER, 2000.

CERTIFICATION

This is to certify that this project work was carried out by ***Ibrahim Sani MAT. NO. 96/5665/EE*** and that the project has met the minimum standard acceptable by the department of Electrical and computer Engineering, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

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HEAD OF DEPARTMENT DATE

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EXTERNAL EXAMINER DATE

DEDICATION

This project work is dedicated to my family particularly my mother Hadjia KOUBOURA, my late father MALAM SANI, my wife SALAMATOU and my children HABIBOU, RAMATOU, MOCTAR, AND NANA RAHIBA MAY THE ALMIGHTY ALLAH BLESS THEM

ABSTRACT

Although the supply of Niamey is largely covered by imported power up till now, it is very important to study the trend of evolution of power to be generated and consumed in order to plan a good management in this matter.

To achieve this, exhaustive description and analysis of different classes of consumers have been done .On the other hand from data available the load forecasting have been carried out up to year 2000.

May this study be our modest contribution to improve the NIGELEC (Societe Nigerenne d' Electricite) Power Policy.

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CHAPTER ONE

1. GENERAL INTRODUCTION

1.1 PRESENTATION OF NIAMEY

NIAMEY THE NIGER REPUBLIC Capital City is located a 1560 miles from Algiers, 1250 miles from DAKAR, 1000 miles from COTONOU and 690 miles from Lagos.

The number of its population is of around 600,000 inhabitants in 1998. The weather there is very hot, thus the temperature could reach 45^0 c in April.

1.2 INTRODUCTION

A major part of the energy which human society needs today is handled in the form of electrical energy and the system which generates, controls, dispatches and finally consumes this energy is known as the electrical power system. This system has got three distinct sub-systems. These are:

a. Generating subsystem
b. Transmission subsystem
c. Distribution subsystem

The generating part consists of generators and their prime movers, complete with necessary accessories. The generation of electrical energy occurs at voltages ranging from 3kv to 13kv. Exciters and high capacity transformers to step up the generated voltage level into the transmission level are also included in this subsystem.

The transmitting part consists of high voltage and high capacity transmission lines which carry the generated energy through long distances in order of consumption. The voltage level of this part varies from 132kv to 750kv. Regulating transformers to control the active and reactive components of the energy as well as various VAR controlling device are found in this subsystem.

Distributing subsystem starts next and consists of feeders. The voltage of this part can vary from 33kv to 415v

In any given power system the insulation system is never perfect. In this case the function of the power system is not always achieved without interruption. These interruptioOns are known as fault. In order to minimize damages due to faults calculations are often made during the faulted conditions of a system, in order to determine the size of the protective device. The protective devices are usually instrument transformers, circuit breaker and fuses. Relays are also use for controlling and detection of a fault in power system.

1.3 PROJECT OBJECTIVE AND MOTIVATION

The purpose of this project "Power Consumption and Load Forecasting in Niamey" consists of understanding the behaviour of distribution lines, mainly 20kv lines in this case study.

Different calculations will permit to observe the network functioning during the period of " power peak" in April at Niamey.

Those will permit also to determine parameter such as overhead lines and cables, network losses various statistics necessary for power management amongst others.

In short the objective of this project will offer us valuable information regarding the parameter listed above so that we can plan the system expansion, hence a good power distribution management.

1.4 LITERATURE SURVEY

Human civilized progress has historically been in proportion to the human ability to control energy. Humanity can feed itself through the efforts of a small of the population only because we know how to channel sufficient into these activities.

The forms energy assumes in nature are manifold, including:

- Radiant – the most obvious example is sunlight
- Thermal energy stored in the earth's interior.
- Chemical – the energy content of fuel as wood, coal, and oil is stored in chemical form.
- Kinetic – moving bodies, such as plants revolving in their orbits, represent energy.
- Potential – any system with forces varying with position has potential energy.
- Nuclear – forces that bind atom parts together relate to energy.
- Electrical – an example of "natural" is lightning.

All those listed above are natural sources of energy. What is needed are technologies that can channel

energy into beneficial applications? We require light sources, cooling and heating capability, transportation systems, communication system, individual and manufacturing processes, construction applications, and agricultural production. All are broad areas of energy use; in each area, energy converted into the electrical energy generation and delivery are and well continue to be of fundamental importance to a technological society, and therefore to engineering.

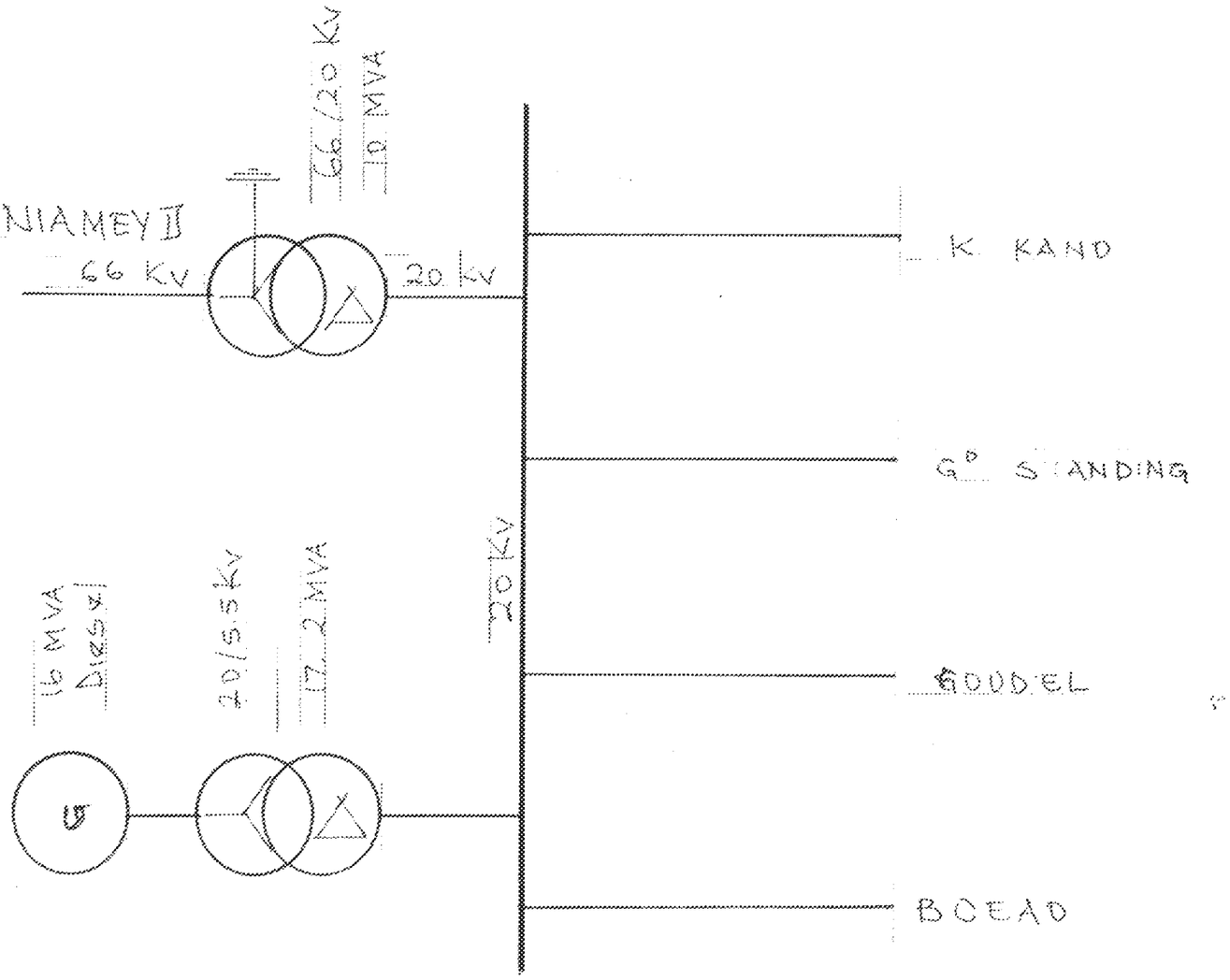
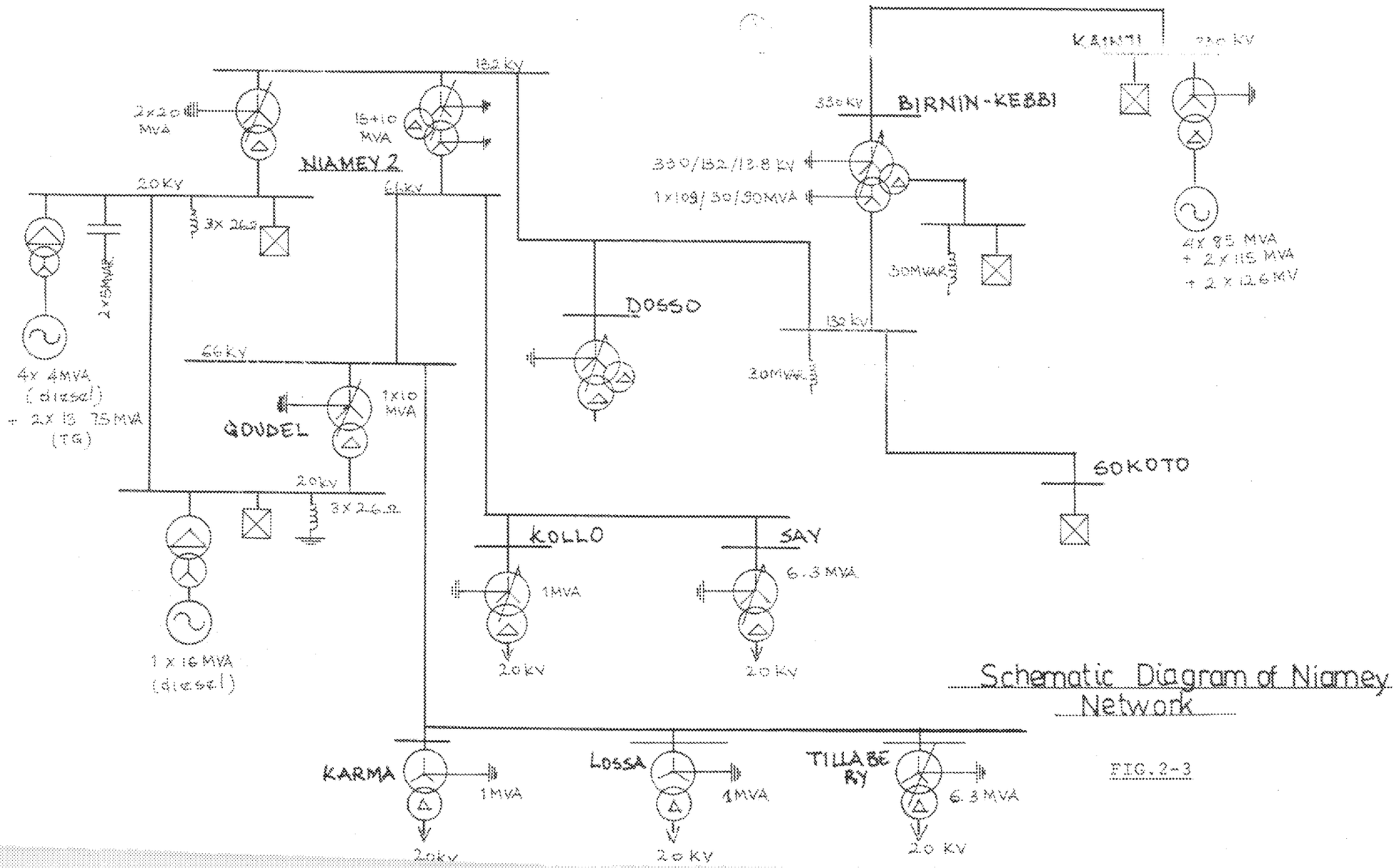


FIG. 2-1

GOUDEL GENERATING POWER STATION



Schematic Diagram of Niamey Network

FIG. 2-3

CHAPTER TWO

2. DESCRIPTION OF NIAMEY NETWORK (20KV LINES)

There are two (2) transmission substations:

- 132KV/66KV/20KV (NAIMEY II)
- 66KV/20KV (GOUDEL)

Overhead line 66kv (NIAMEY-GOUDEL) busbarss 66KV (NAIMEY-GOUDEL)

COMPOSITION OF THE NETWORK

- Two (2) transmission substations
- Five (5) power transformers
- 719 electric nodes
- 450 distribution transformers
- 761 sections of overhead and underground lines
- 12 types of lines

NOTE: length less than 40m is neglected.

OVERHEAD lines and cables. The actual network of Niamey is consisted of around: 263.5km (overhead and underground lines) in which we have 167.5km for overhead lines and 96km for underground cables.

Sharing out from type and nature of conductors.

Conductors		Total length tri-phase lines (km)
Cable 150mm^2 (AL)	-	91.311
Cable 70mm^2 (Cu)	-	2.280
Cable 25mm^2 (Cu)	-	2.395
Overhead 75.5mm^2 (Al)	-	50.065
Overhead 54.6mm^2 (Al)	-	11.175
Overhead 34.4mm^2 (Al)	-	60.995
Overhead 48mm^2 (Cu)	-	8.250
Overhead 28mm^2 (Cu)	-	0.290
Overhead 22mm^2 (Cu)	-	7.485
Overhead 14mm^2 (Cu)	-	10.470
Overhead 147mm^2 ALUAC (66KV)	-	8.800
Overhead 117mm^2 (AL) (66KV)		10.000
		263.516 KM

Values of currents and resistance are determined using temperature as bel

- Overhead line Cu: 70^{0}C, 40^{0}C
- Overhead line Almelec 80^{0}C, 40^{0}C
- Insulated paper cable 60^{0}C
- Cable XLPE 90^{0}C

POWER TRANSFORMERS

NIAMEY II

- Transformer 132KV/20KV MAF WESTINGHOUSE
- YEAR:1977

Nominal Power : 20MVA

No load Ratio : 132KV/20KV

Tap Changer : 17 positions on HV ≠ 15%.

- Transformer (MITEL) 132KV/66KV/20K

year 1979

Coil resistance 9.12

Use at 75°C, 10%

Active power losses on no load, Po = 14.4KW

No load ratio 132KV/66KV

Connection group vectors Yn Yo d5

Tap changer type MRMIII X 300

Cde MAF 33 positions on HV 1.75%

- Transformer (OMAN PAUWEL TRAFO) 132KV/66KV
- year: /

No load ration 132KV/66KV

Nominal power Sn = 15MVA

Tap changer type MRMIII 3300, 33 positions on HV

Connection group vectors Yn Yn d5

Power transformers located in towns surrounding Niamey.

GOUDEL

Transformer (SONICEM) 66KV/20KV

Year : 1982

No load ratio : 66KV/20KV

Nominal Power 10MVA

Connection group vectors Yn d5

Tap changer type MRV – 25 positions

LOSSA

Transformer (CEM) 66KV/20KV/0.4KV

Year : 1982

Short circuit tension UsC % = 8 of 10%

Guaranteed iron losses Pi = 1.9KW

Guaranteed copper losses Pc = 13.0KW

No load ratio: 66KV/20KV/0.4KV

Nominal power Sm – 1MVA

Connection group vectors Yn Dii Yn0

Tap changer: not working

Active power losses on no load: 4.7KW

TILL A BERY

Transformer (MINAL) 66KV/20KV

Year : 1980

Coil resistance 3.67

Use at 75°C 8% at power losses on no load Po = 7790W

No load ratio : 66kv/20kv

Nominal power sn = 6.3 MVA

Connection group vectors Yn d5

Tap changer with 25 positions

Primary side + . 1 2 X 12.

KOLLO

Transformer (PAUWEL TRAPO) 66KV/20KV year: 1985

No load ratio: 66KV/20KV

Nominal power: Sm = MVA

Connection group vectors: Yn dl

Tap changer: no working

SAY

Transformer (PAUWEL TRAFO) 66KV/20KV

year: 1985

No load ratio: 66KV/20KV

Nominal power: Sn = 6.3 MVA

Connection group vector Yn dl

Tap changer type ORS with 17 positions.

DOSSO

Transformer (ONAW) 132KV/20KV/380V

year: /

No load ratio: 132KV/20KV/0.38KV

Connection group vectors

(i) Primary to secondary : YyO

(ii) Primary to thirdly : Yd1

Tap changer : HT side from - 15%

(112KV) to + 5% (138 KV)

Minimum number of sockets 13.

2.1 Big consumers of Niamey and their influence on Niamey "power peak"

In general consumers can be classified into six (6) main categories which are:

- Administration (Administrative)
- Industrie (Industrial)
- Commerce-artisonat (Commercial)
- Residentielle (Residential)
- Hotel (Hotel)
- Divers (Others)

After this classification, let take the consumption of year 1995 and consider as big consumer each consumer who get maximal power Pmax greater than 200KW.

Therefore, this will give us the following table for 52 big consumers. (TABLE 2-1)

Table 2-1

S/NO	TRANSFORMER	ZONE	PMAX (KW)	P (KW)	PCUM (KW)
1.	STADE CMISPO	INDL	2604	2322	322
2.	CNSS	ADM	2010	1613	935
3.	NITEX	IND	1746	1125	060
4.	HOTEL GAWEYE	HOT	1160	847	907
5.	BCEAO IMMEUBL	ADM	1020	818	726
6.	NOUVELLE BDRN	ADM	750	602	328
7.	CHU	COMB	680	606	934
8.	SPG	IND	801	515	451
9.	PALAIS CONGRES	INDL	600	535	985
10.	EMIG	COMB	520	464	449
11.	ONAREM 2	ADM	540	433	882
12.	SONARA 2	COMB	447	399	0281
13.	SONICERAM	IND	568	366	0647
14.	BRANIGER 1	IND	560	361	1008
15.	HOPITAL 2	COMB	400	357	1365
16.	OLANI	IND	500	322	1687
17.	SPY	IND	500	322	2009
18.	MP	ADM	380	305	2314
19.	AGRHYMET	ADM	376	302	2616
20.	PREFECTURE	COMB	338	301	2917
21.	COURLAFONTA	COMB	300	268	3185
22.	MAE/C	ADM	300	241	3425
23.	ECOLE PEDAGO	ADM	300	241	3666
24.	TELE SAHEL	IND	360	232	3898
25.	SCOA	ART	320	228	4125
26.	BIAO NIGER	ADM	283	227	4353
27.	MOULIN SHAEL	IND	340	219	4572
28.	PRIMATURE	ADM	272	218	4790
29.	CINE HD	COMB	245	218	5009
30.	KABE KOIRA	RES	366	213	5222
31.	FINANCES	ADM	261	209	5431
32.	TPSOM	COMB	232	207	5638

33.	LEYMA	ADM	234	188	5826
34.	NIG ELEC	ADM	229	184	6009
35.	SNTN GARAGE	ADM	225	181	6190
36.	TP BATIMENT	ADM	225	181	6371
37.	YANTALA NORD	RES	307	179	6549
38.	SONARAI	COMB	201	179	6728
39.	AMBAS-FRANCE	COMB	200	178	6907
40.	TERMINUS	HOT	234	171	7078
41.	GRD MARCHE 1	ART	237	169	7246
42.	GRD MARCHE 2	ART	237	169	7415
43.	EDUCATIONN	ADM	210	169	7583
44.	AMB-USA	ADM	200	160	7744
45.	USAID	ADM	200	160	1 904
46.	SPCN	IND	240	155	8059
47.	JEUNES CADRES	RES	247	144	1 203
48.	YANTALAEST	RES	246	143	1 346
49.	ONPPC Z1	IND	215	139	1 484
50.	MARADI	RES	230	134	1 618
51.	PI 53	RES	212	123	1 742
52.	PI 54	RES	212	123	1 865

SOURCE: SOCIETE GENERALE POUR L'INDUSTRIE/INGENIEURS CONSEILS (GENEVE SUISSE) (1995)

According tot he table I we remark clearly the influence of big power consumers in the "power peak".

From the example as follows: -

- 5 bigger consumers consume 6.7MW
- 10 bigger consumers consume 9.4MW
- 20 bigger consumers consume 12.9MW
- 50 bigger consumers consume 18.6MW

On the other hand, table II shows the power consumption by category along 24 hours on 27/04/1995.

TABLE 2-2 (MW)

HOUR	*ADM*	*IND*	*COMM*	*RESID*	*HOT*	*OTHERS*	*TOTAL*
1.	3.36	3.58	0.78	5.82	1.14	7.54	22.20
2.	3.33	3.56	0.79	5.36	1.08	7.39	21.50
3.	3.44	2.61	0.81	5.40	1.15	7.39	20.00
4.	3.36	2.80	0.80	5.08	1.00	6.95	19.20
5.	3.22	3.07	0.80	4.77	0.96	6.38	18.80
6.	3.16	3.33	0.65	4.68	0.96	6.02	21.50
7.	3.33	3.85	0.66	5.27	1.02	7.39	27.40
8.	6.56	4.12	1.43	5.08	1.15	9.06	34.80
9.	8.76	4.82	1.85	5.92	1.16	12.29	36.30
10.	9.58	4.86	2.02	5.87	1.48	12.49	37.50
11.	9.88	5.47	2.20	6.21	1.31	12.44	37.80
12.	10.57 →	5.54 →	2.25	5.54	1.28	12.58	30.90
13.	8.60	5.37	1.17	5.36	1.42	9.12	30.70
14.	8.14	4.07	1.19	5.61	1.42	9.27	31.60
15.	8.82	4.55	1.44	5.09	1.54	10.17	30.70
16. →	12.81	4.61	1.89	5.85	1.52 →	13.11	31.60
17.	11.42	3.72	1.76	5.51	1.30	9.27 →	39.80
18.	11.42	3.95	1.80	5.90	1.40	10.80	33.00
19.	5.29	3.75	1.31	5.94	1.28	7.04	35.30
20	4.39	3.91	0.88 →	7.74	1.46	8.43	24.60
21.	3.75	3.39	0.81	7.42	1.28	6.86	26.80
22.	3.19	3.26	0.75	7.40 →	1.23	7.28	23.50
23.	3.45	3.11	0.86	7.21	1.41	7.17	23.50
24.	3.32	3.39	0.70.	6.45	1.25	7.19	23.20
							22.30

SOURCE : SOCIETE GENERALE POUR L' INDUSTRIE /INGENIEURS -CONSEILS (GENEVE SUISSE) 1995.

NOTE: The arrow shows the power peak for each categories and the total power is equal 39.80 MW at 4pm (16h).

In general, the power consumption can be presented as follows:

Total power installed within 450 transformer (MV/LV) = 133.305KVA

- Total active power = 38952KW
- Total reactive power = 28383 KVAR
- Total apparent power = 48A96KVA
- Power factor = 0.808

2.2 COMPENSATION OF REACTIVE POWER

The aim of this, is to study the influence of capautors used at large scale on 20KV lines (network). Those are placed on LV sides of MV/LV transformers. As we have observed previously the power factor (PF) in equal 0,808 which is too low economically. For instance, we have systematically a minimum PF = 0.9 in transformers, which are, delivered active power greater than 200KW (Big consumers). In order to achieve this objective .

83 units of 50kvAR each totaling 4150KVVAR are installed as follows:

Adminisation transformers	-	1700KVAR
Combined transformers	-	1000KVAR
Industry transformers	-	650KVAR
Hotel transformers	-	400KVAR
Commercial transformers	-	300KVAR
Residential transformers	-	100KVAR
Total	-	4150KVAR

Result comparison with total assessment can be presented like that:

TABLE 2-3	Before compensation	After compensation
Active power	38952KW	38952KW
Reactive power	28383KVAR	24233KVAR
Apparent power	48196KVA	45874KVA
Power factors	0.808	0.850
Active power losers	952KW	830KW

Source NIGELEC (1995)

From table iii, we remark a difference of 4150KVA in terms of reactive power, which is quite important. Also active power losers are reduced with 122KW.

2.3 STATISTICAL ANALYSIS

To carry out this analysis histogram are plotted using table II which shows the power consumption for six (6) categories of consumers along 24 hours on 27/ 04 / 1995.

Let take A,B, C, D,E and F as histograms, the respective classes of consumers are:

A ------ ADM

B ------- IND

C -------- COMM

D --------- RESID

E --------- HOT

F ---------- OTHERS.

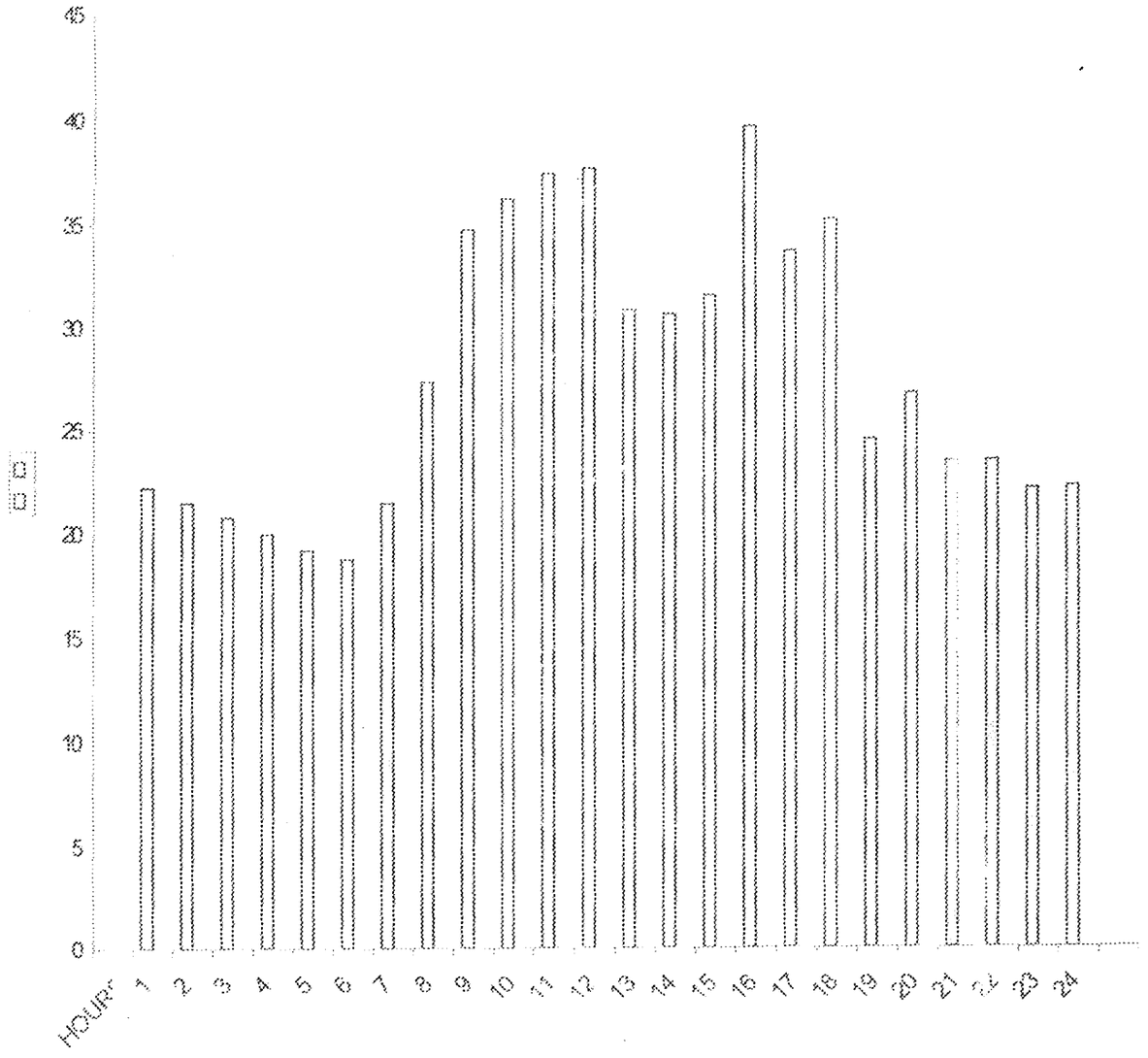

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FIGURE 2.1

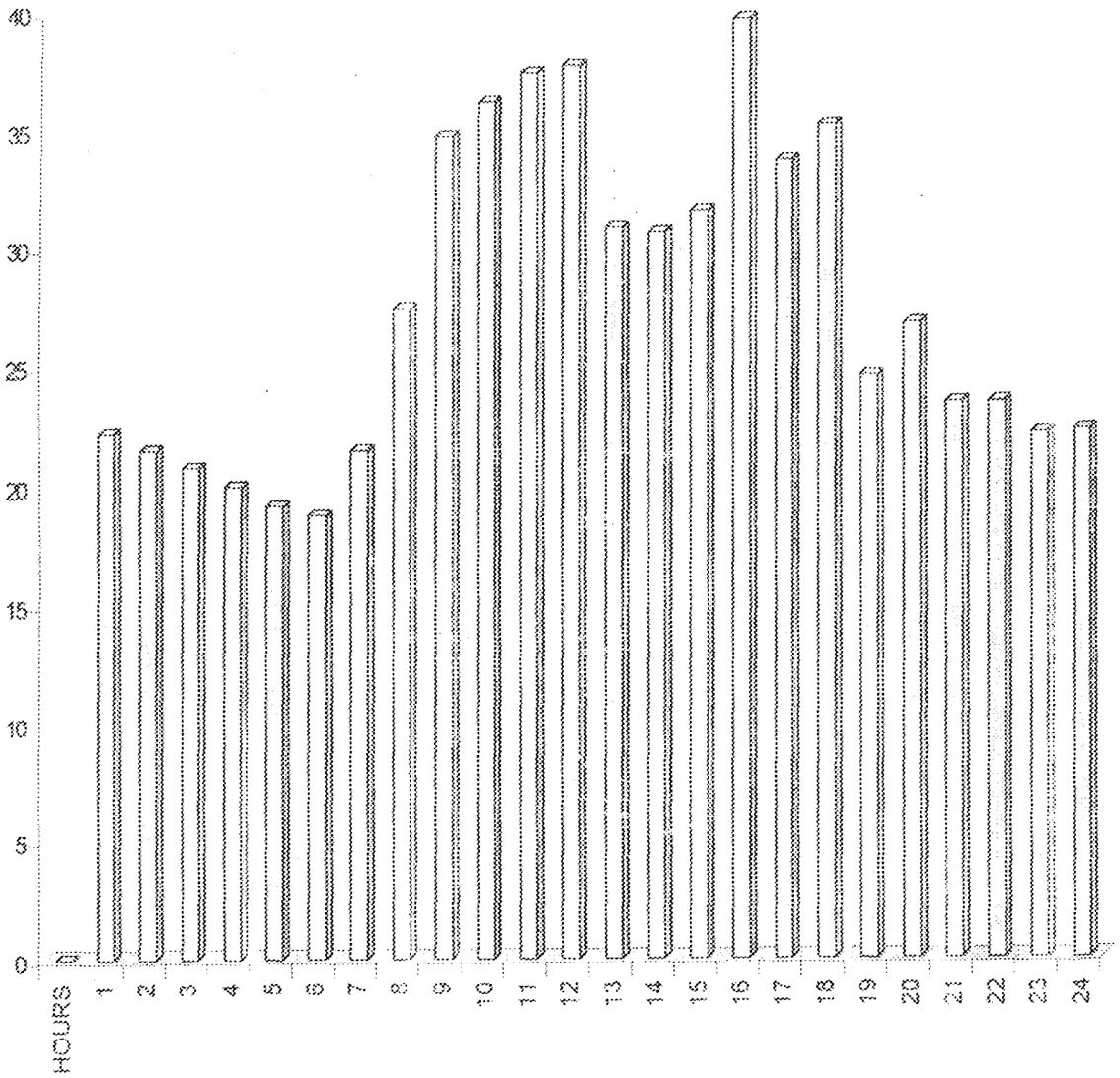

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FIG 2.2

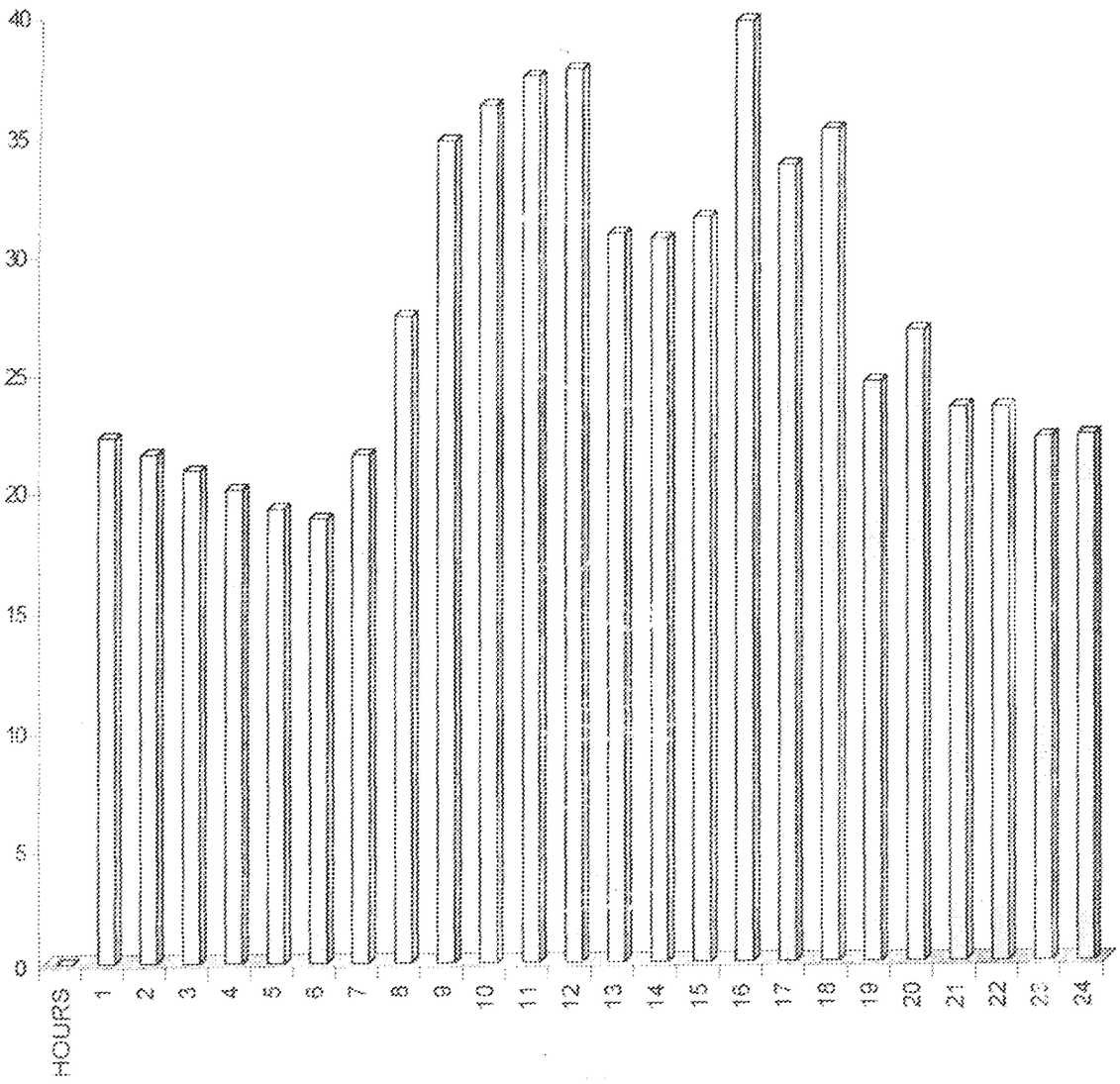

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FIG 2.3

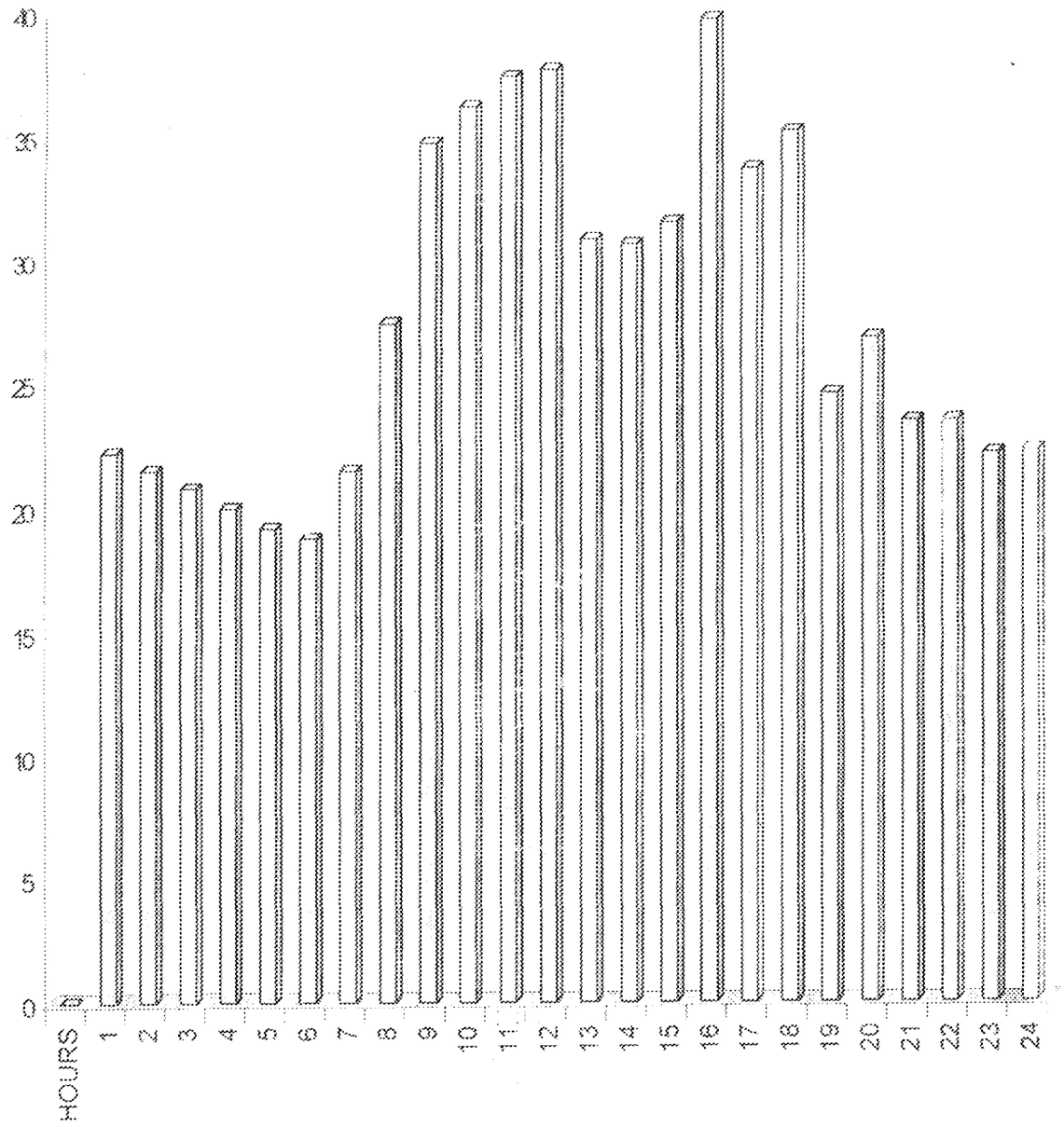

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FIG 2.4

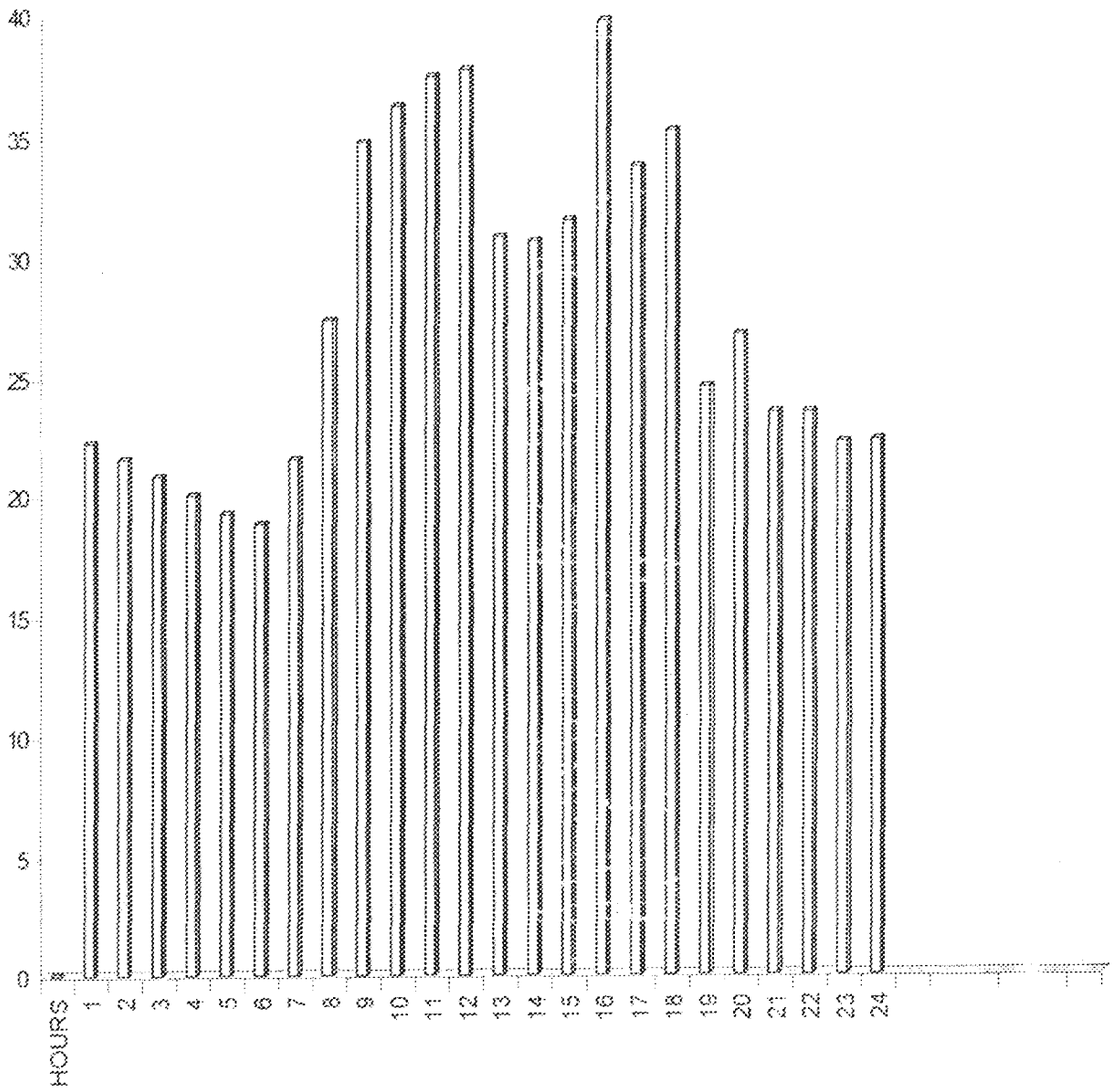

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FIG 2.5

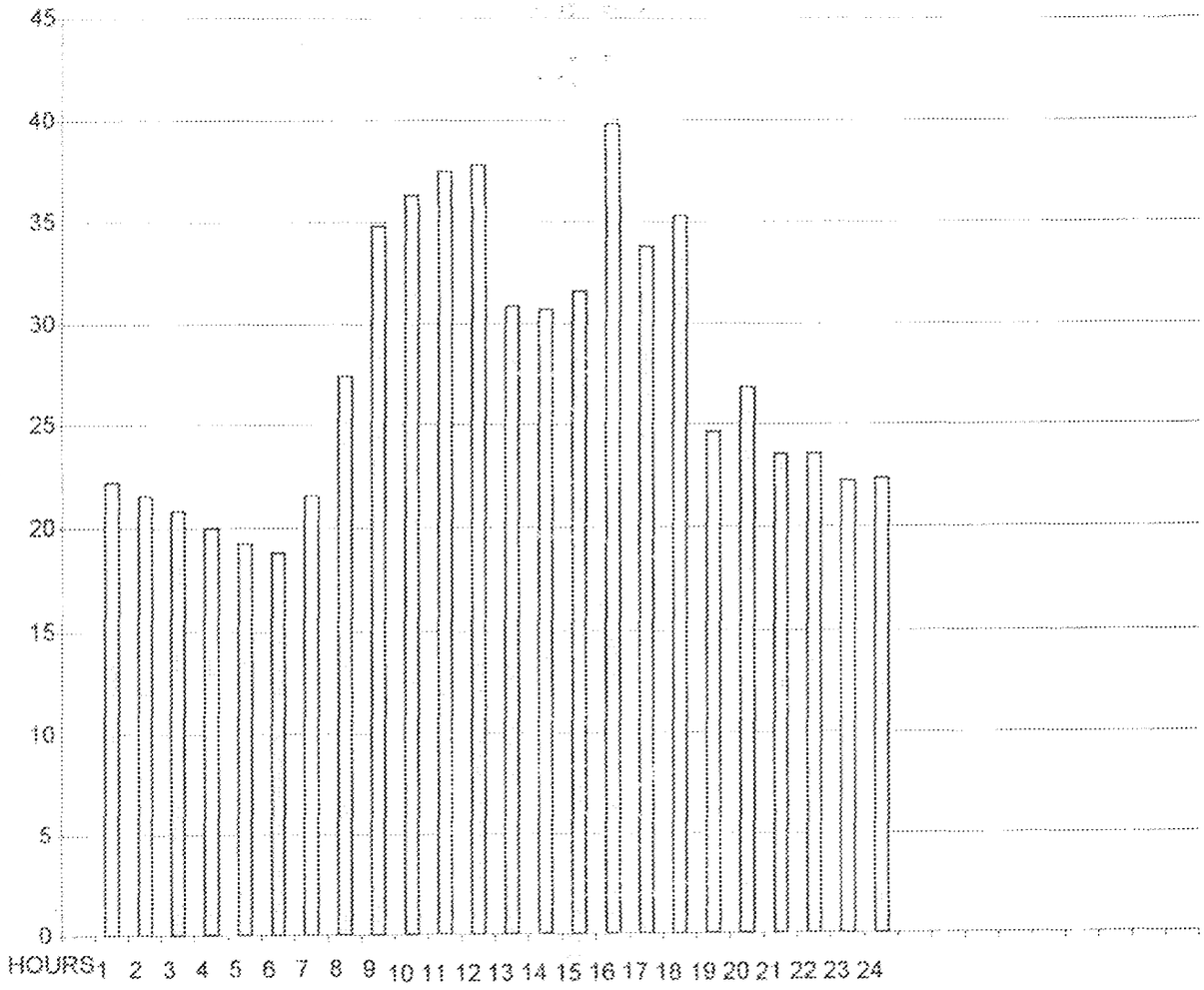

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FIG 2.6

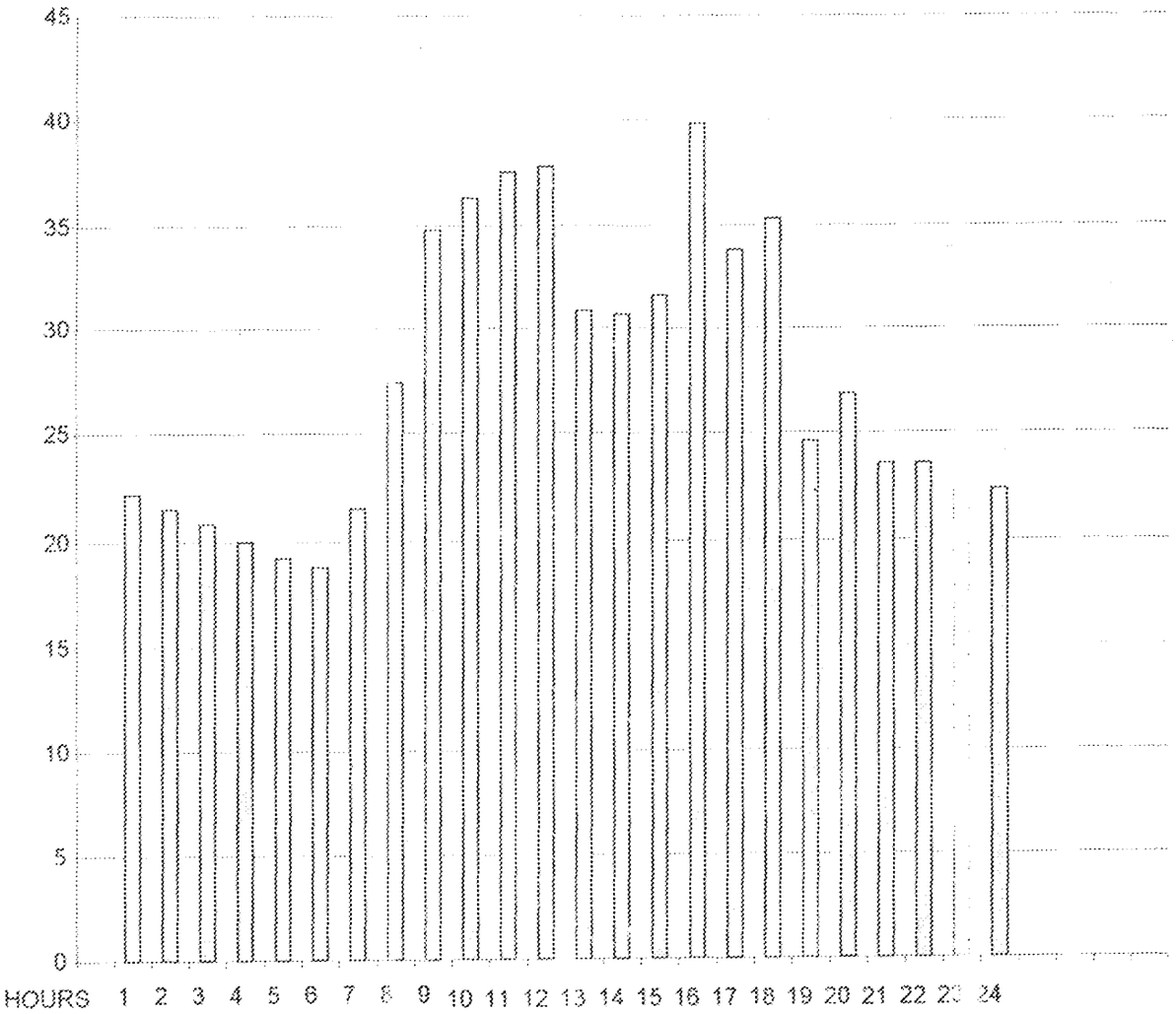

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FIG 2.7 (TOTAL)

CHAPTER THREE

ALTHOUGH there is no major problem in terms of power supply at Niamey up to now there is a need for accurate forecasting of energy to conform the modern management . Let take as work basis the energy generated and consumed at that place from 1980 to 1990 as shown by table 3.1 below.

TABLE 3.1

YEAR	*ENERGY GENERATED (MWH)*	*ENERGY CONSUMED (MWH)*
1980	107000	34561
1981	121000	41140
1982	134000	38860
1983	131000	40610
1984	131000	43230
1985	132000	38940
1986	133000	42294
1987	139000	47322
1988	147000	45746
1989	156000	54802.8
1990	156800	58761.6

Source : NIGELEC NIAMEY (1991)

To do our calculations we have chosen two-methods of forecasting.

3.1 LINEAR REGRESSION METHOD

A linear relationship is formed between the energy consumption (dependant) variable and time (independant) variable to arrive at a final straight-line equation.

$Y = ax+b$

The evaluation of constants a and b using least square approach , according to Stroud (1976) are:

$$a = \frac{n \Sigma xi \Sigma yi - \Sigma xi \Sigma yi}{a \Sigma xi^2 \Sigma yi (\Sigma xi)^2}$$

$$b = \frac{\Sigma xi2 \Sigma yi - \Sigma xiyi \Sigma xi}{n \Sigma xi^2 - (\Sigma xi)^2}$$

3.2 LOGARITHMIC METHOD

For this system the relationship is:

$$Y = ab^x$$

Introducing logarithm into the equation

$$\text{Logy} = \text{loga} + x\text{logb}.$$

Then

$$\text{Loga} = \frac{\Sigma xi2 \Sigma logyi - \Sigma xlogyi \Sigma logxi.}{n\Sigma xi^2 - (\Sigma xi)^2}$$

$$\text{Logb} = \frac{\text{"}\Sigma xilogyi - \Sigma xi \Sigma logyi}{n\Sigma xi^2 - (\Sigma xi)^2}$$

$$\text{And } y = 10^{(\text{loga}+x\ \text{logb})}$$

In this particular case, to carry out our calculations a Casio fx 100 scientific calculator has been used.

For linear regression we get in energy generated.

a	=	-7.913×10^{6}	(a= constant)
b	=	$4.0.545 \times 10^{3}$	(b= constant)
r	=	0.9276	(r= correlation coefficient)

While in energy consumed, we get

a	=	-3.724×10^{6}
b	=	1.898×10^{3}
r	=	0.879

For logarithmic regression, we also get in energy generated

a	=	-60.976x106
b	=	8.048×10^{6}
r	=	0.928 while in energy consumed
a	=	34550677
b	=	1398.675
R	=	0.44

The results obtained are shown below respectively in table 3.2, 3.3, 3.4, 3.5. as follows:

TABLE: 3.2

Linear regression for energy expected to have been generated between 1990 to 1999.

Years	Energy expected to have been generated (MWH)	Energy expected to have been consumed (MWH)
1991	159581. 82	55595.265
1992	163636.36	57493.458
1993	167690.91	59391.651
1994	171745.46	61289.844
1995	175800.00	63188.036
1996	179854.55	65086.229
1997	183909.09	66984.422
1998	187963.64	68882.615
1999	192018.18	70780.807

TABLE; 3.3

Linear regression for energy expected to the generated between 2000 – 2020

Year	***Energy to the generated (MWH)***	***Energy to the consumed (MWH)***
2000	196072. 73	72679.000
2001	200127 .28	74577.193
2002	204181 .82	76475.385
2003	208236.36	78373.578
2004	212290.91	80271.771
2005	216345.46	82169.964
2006	22040.00	84068.156
2007	224454.55	8596.349
2008	228509.09	87864.542
2009	232563.63	89762.735
2010	236618.8	91660.927
2011	240672.73	93559.120
2012	244727.27	95457.313
2013	248781.82	97355.505
2014	252836.36	99253.698
2015	256890.31	101151.891
1016	260545.46	103050.084
2017	265000.00	104948.276
2018	269054.55	106846.469
2019	273109.09	108 744.662
2020	277163.64	110642.855

CURVES

FIG 4

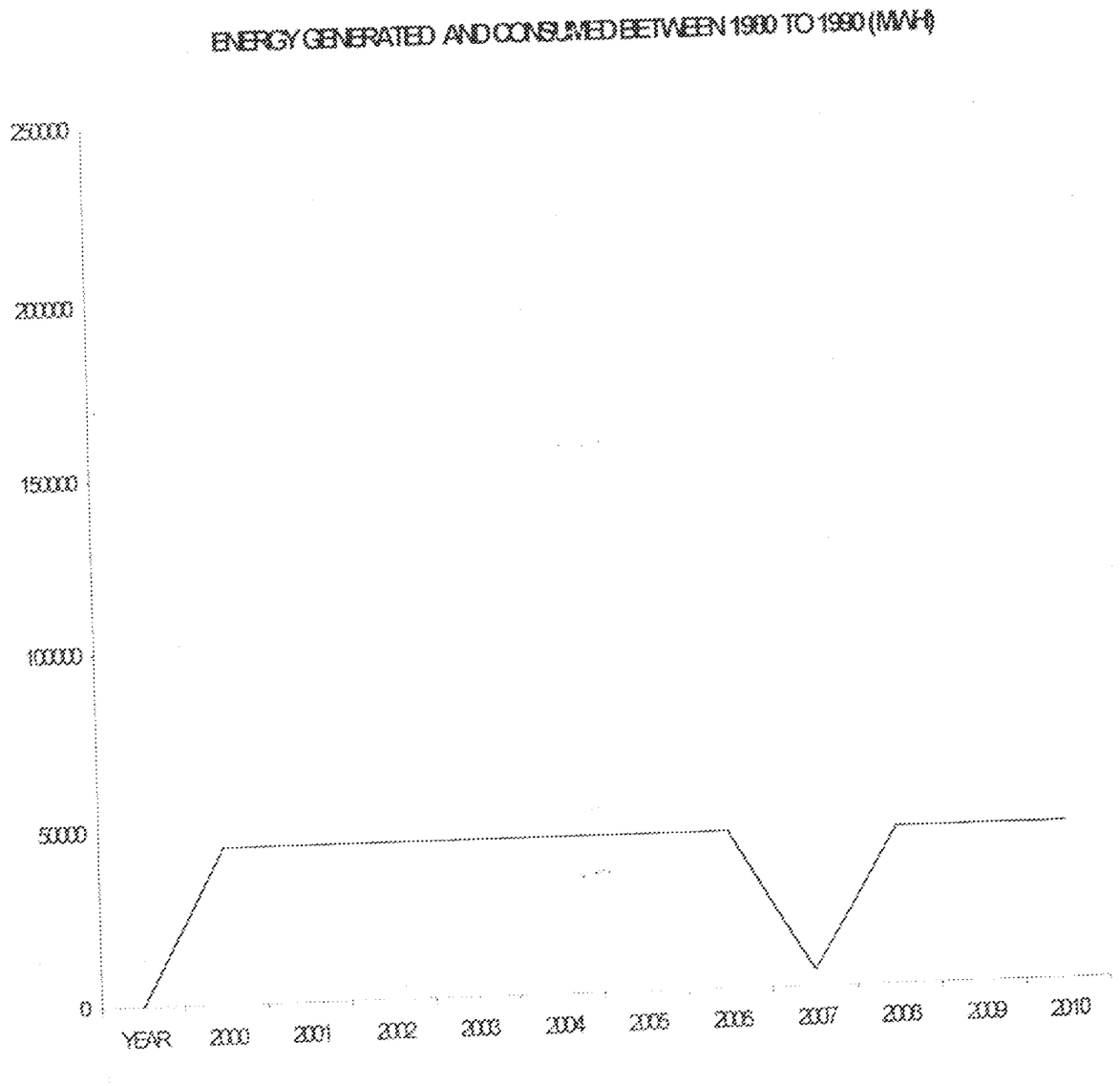


FIG 3-6

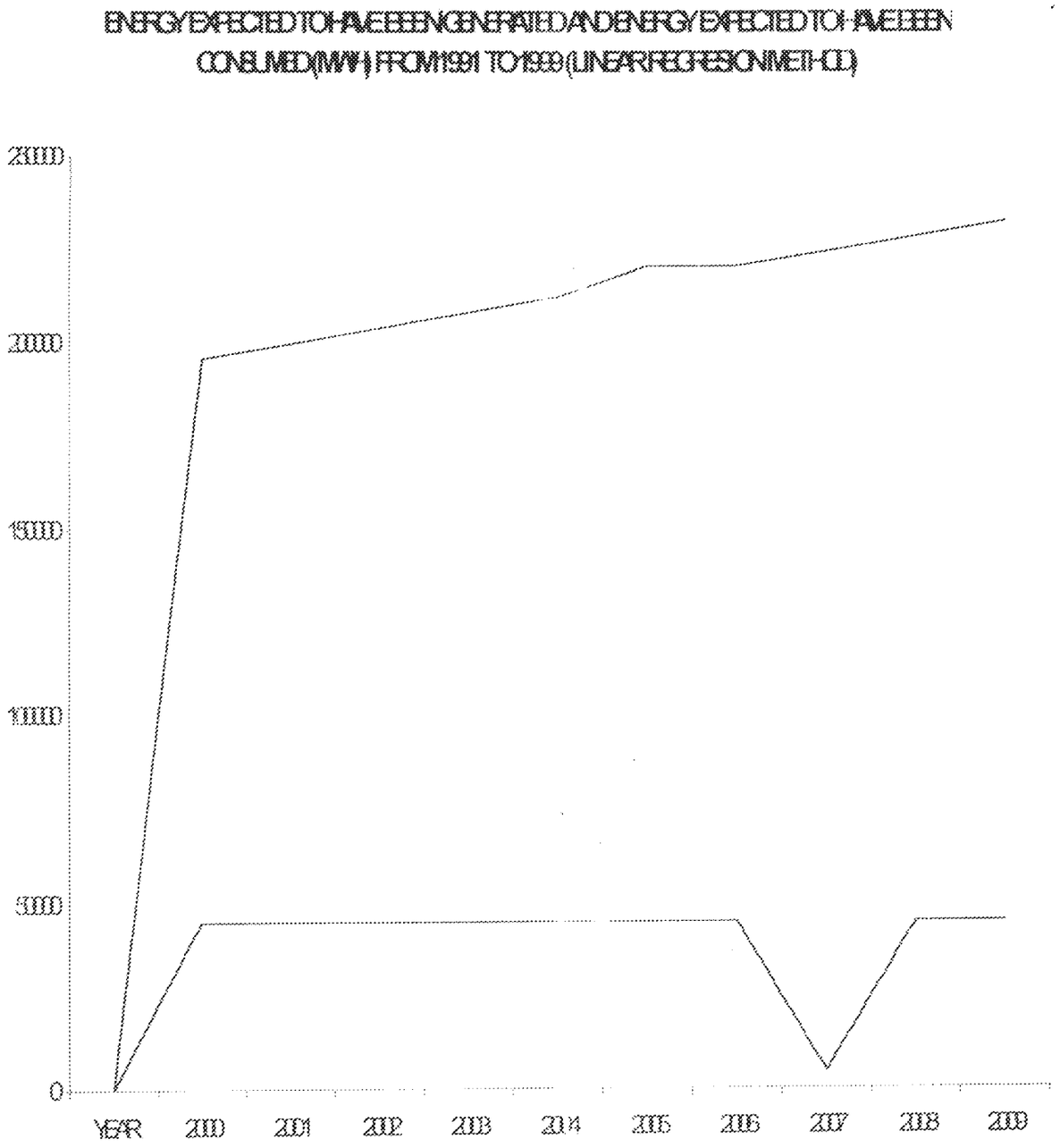

ENERGY EXPECTED TO HAVE BEEN GENERATED AND ENERGY EXPECTED TO HAVE BEEN CONSUMED (MW) FROM 1991 TO 1999 (LINEAR REGRESSION METHOD)
20000
15000
10000
5000
0
YEAR
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009

FIG 3-7

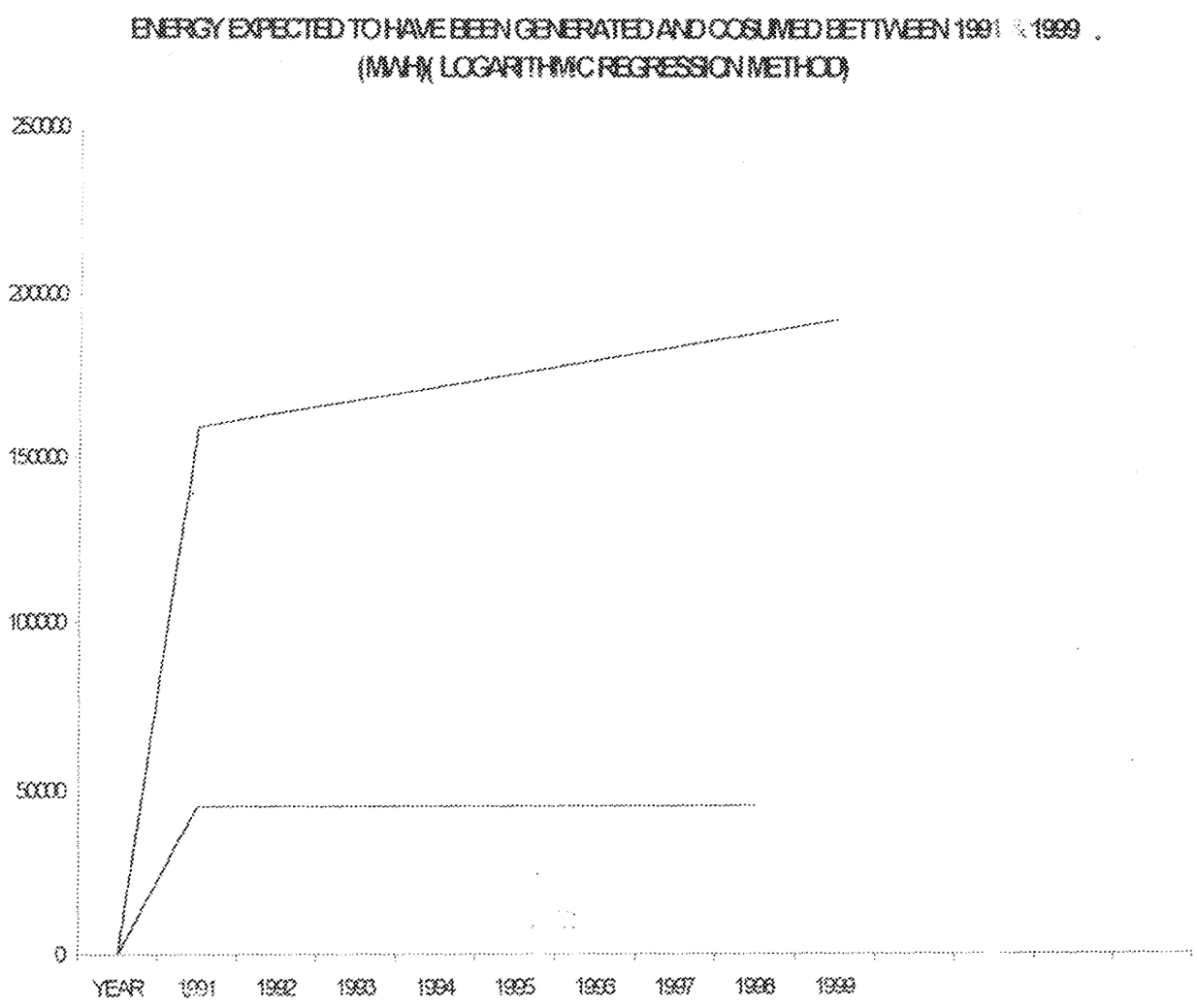

ENERGY EXPECTED TO HAVE BEEN GENERATED AND CONSUMED BETTWEEN 1991 & 1999 .
(MWH)(LOGARITHMIC REGRESSION METHOD)
250000
200000
150000
100000
50000
0
YEAR
1991
1992
1993
1994
1995
1996
1997
1998
1999

FIG 3-9

ENERGY TO BE GENERATED AND CONSUMED BETWEEN 2000 &2020 (MWH) (LOGARITHMIC REGRESSION METHOD)

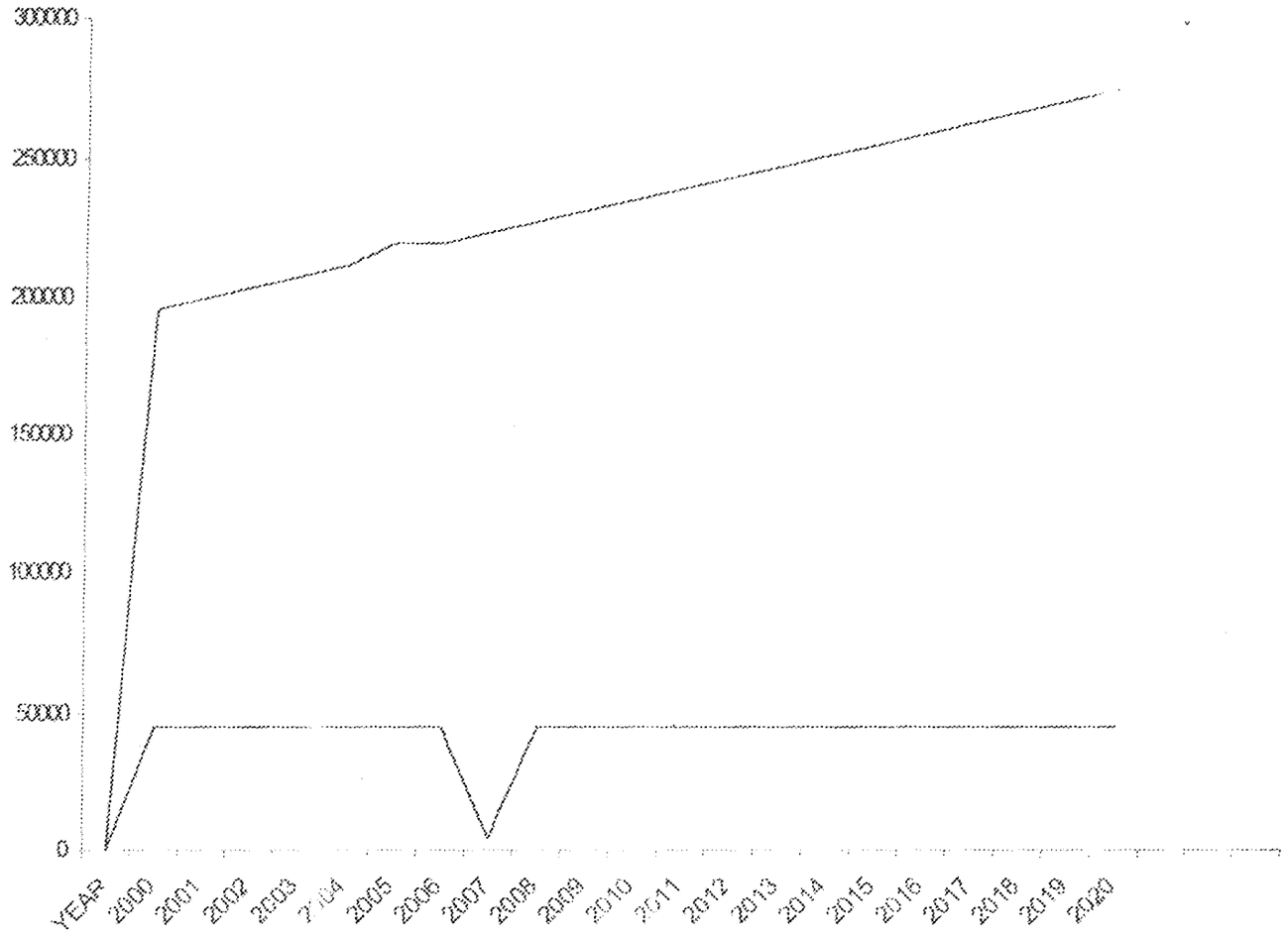


FIG 3-10

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