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UNIVERSIDAD NACIONAL DE INGENIERIA
FACULTAD DE INGENIERIA AMBIENTAL
Av. Tupac Amaru s/n Aptdo. 1301
Lima, Perú
Fax 821585

PB99-109910

PROJECT: PERU CLIMATE CHANGE COUNTRY STUDY

PERU MITIGATION ASSESSMENT OF GREENHOUSE GASES
SECTOR : *ENERGY*

Final Mitigation Report

. *Universidad Nacional de Ingeniería (Facultad de Ingeniería Ambiental)*

. *Instituto Peruano de Energía Nuclear*

. *Servicio Nacional de Meteorología e Hidrología*

National Staff :

1. JORGE RUIZ BOTTO , Project Manager
2. CESAR PIZARRO CASTRO
3. JUAN AVILA LOPEZ
4. IVAN LLAMAS MONTOYA
5. JORGE PONCE URQUIZA
6. ELIZABETH CULQUI DIAZ
7. NESTOR TEVES RIVAS

Lima, August, 1996

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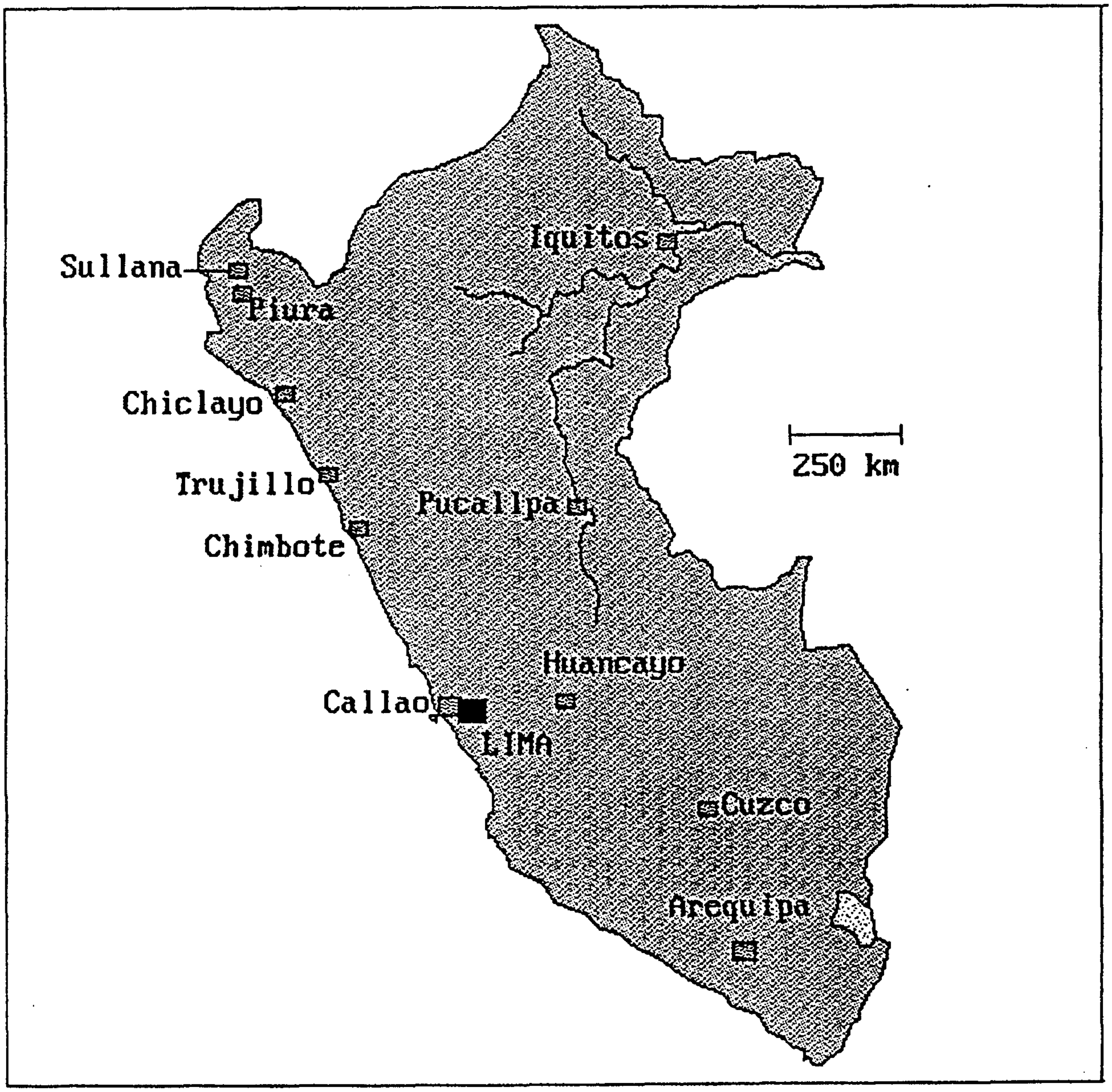
PERU CLIMATE CHANGE COUNTRY STUDY



PERU MITIGATION ASSESSMENT OF GREENHOUSE GASES

Lima, August 1996

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EXECUTIVE SUMMARY

Perú has carried out the project PERU CLIMATE CHANGE COUNTRY STUDY co-sponsored by the U.S. Country Studies Program and under the bilateral cooperative agreement Nr. DE-FCO-94PO1029, developing the INVENTORY and MITIGATION major studies of Greenhouse Gases (GHG) and the Vulnerability of the Peruvian coast.

The aim of this study is to determine the Inventory and propose Greenhouse Gases Mitigation alternatives in order to face the future development of the country in a clean enviromental setting without delaying the development process required to improve Peruvian standard of living. The main idea of this executive abstract is to show concisely the results of the Greenhouse Gases Mitigation for Peru in the period 1990 - 2015. In order to achieve efficiency and organizational purposes, the study has been divided in : Element I: Energy Sector, Element II: Non energy Sector and Element III: Peruvian Coast Vulnerability. The studies about mitigation for the Energy Sector are shown in this summary.

1990 was stablished as the base year in accordance with the United States, cofinancing agent of this project, and within the objectives of the Convention about Climate Change of the United Nations carried out in Rio of Janeiro in 1992.

MITIGATION BASE SCENARIO

A mitigation base scenario, which is used as a reference for mitigation options, has been elaborated in order to quantify the Greenhouse Gases. This scenario is based on the most probable Gross Domestic Product growth (GDP), the population increase and the energy demand for the base year. The ENPEP model has been applied with this information. This model has been developed by the Argon National Laboratory (ANL) aimed to accomplish energy and enviromental studies.

Gross Domestic Product (GDP)

The base scenario is based on the probable country development, that is to say, in the total and sectorial Gross Domestic Product growth and by sectors assigned by the goverment. For the present study the macroeconomic scenario foreseen by the Ministry of Economy and Finances has been used which is also applied by the Ministry of Energy and Mines in its energy projections.

Figure ES-1 shows the total GDP in new soles of 1990 projected for 1990 - 2015 period.

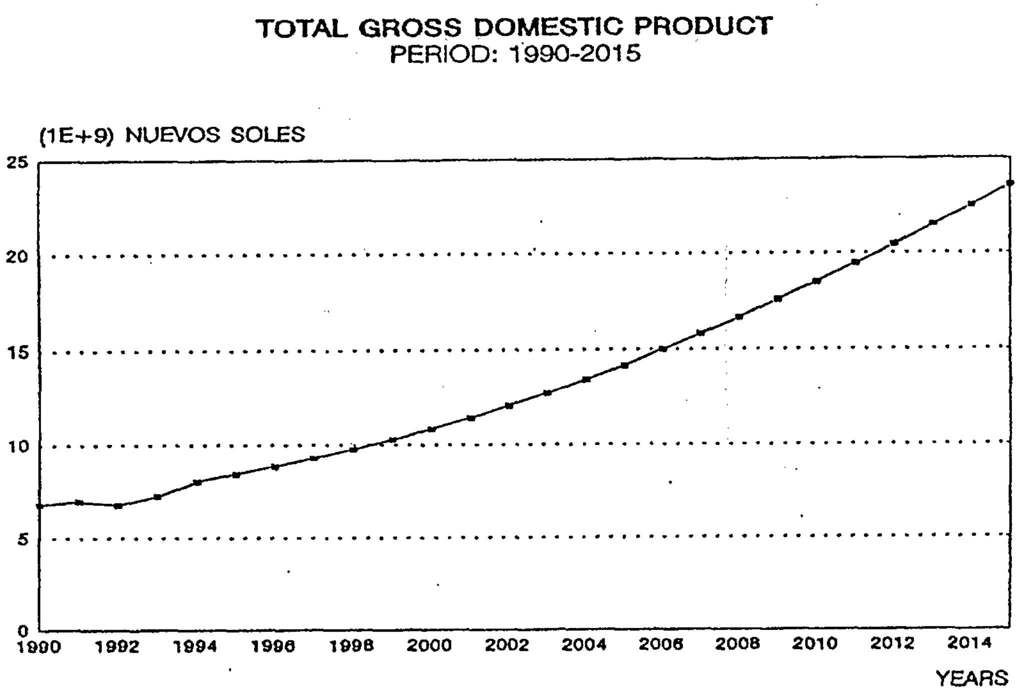

Fig. ES-1 Projected gross domestic product in new soles of 1990 for the period in between 1990 and 2015.

Population Statistics

The base scenario is also based on the population growth, since the population consumes energy and has a direct influence in the energy requirement of Greenhouse Gases. For this study, up dated statistics from the National Institute of Statistic and Informatics (INEI)has been applied. The growth of Urban and Rural Population has been considered in a separate manner, since they use different energy fuels and have different growths.

Figure ES-2 shows the Rural and Urban projection, obtained by using the methodology of the National Institute of Statistics and Informatics forthe period between 1990- 2015.

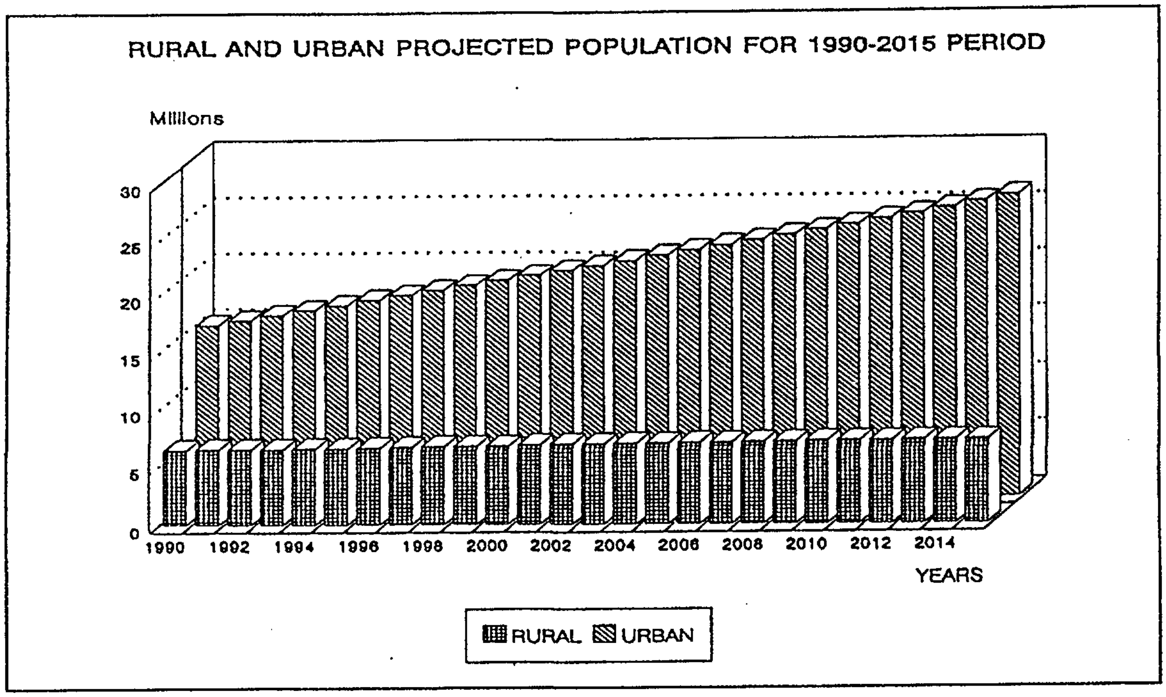

Fig. ES-2 Projected Urban and rural population for the Period 1990-2015.

Energy Demand for the Base Year

The ENPEP model requires the stablishment of a base year,so according to the Cooperative Agreement beetwen USA-PERU for the project "PERU CLIMATE CHANGE COUNTRY STUDY" (PCS) and the Agreement celebrated under the frame of the meeting celebrated in Rio of Janeiro in 1992, 1990 was the elected year.

Table ES-1 shows the energy consumption for the base year, it was organized according to the ENPEP model and was taken from the energy balance of 1990. For the mitigation studies, the representation of sectors - used to accomplish the inventory of the Greenhouse Gases of the present project (PCS)- has been modified. It was necessary to take into account this aspect due to the influence noticed on the Residential Sector and specially on the Rural Population in respect to the energy consumption. For this reason this sector has been divided into : Residential, Urban and Rural. Therefore, in order to carry out further studies,Transportation and Fishing Sectors have been also divided into subsectors: Passenger Transportation, Road Transportation, Fishing Extraction and Fishing Transformation.

ENERGY CONSUMPTION IN THE YEAR 1990
UNITS : KBOE

RESOURCE	Residential		Transportation		Industry	Mining	Fishing		Commer Pub. Serv.	Agricult. Industry	TOTAL
	Urban	Rural	Passag.	Frieght			Extracc.	Transf.			
Gasoline	0.00	0.00	5815.86	2787.48	24.48	82.86	2.19	0.00	538.74	18.98	9050.54
Kerosene	3285.60	1647.29	388.88	1227.58	10.22	33.58	0.00	0.00	498.19	1.48	7090.78
LPG	1295.80	23.40	0.00	0.00	0.00	15.33	0.00	0.00	43.71	0.00	1378.24
Diesel	0.00	0.00	2311.58	5245.38	874.52	368.65	275.68	15.59	917.61	135.78	9944.79
Residual	0.00	0.00	79.20	653.72	4082.18	1984.07	0.00	1210.49	165.20	495.74	8870.58
COAL	54.24	0.00	0.00	0.00	354.05	57.31	0.00	0.00	0.00	0.00	465.60
Wood	818.20	19335.06	0.00	0.00	3245.67	0.00	0.00	0.00	5.82	0.00	23404.75
Dung	0.00	1894.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1894.28
Bagasse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	898.73	898.73
Coke	0.00	0.00	0.00	0.00	0.00	195.93	0.00	0.00	0.00	0.00	195.93
Charcoal	107.16	135.64	0.00	0.00	0.00	0.00	0.00	0.00	661.67	0.00	904.47
Distrib. Gas	335.07	0.00	0.00	0.00	207.32	0.00	0.00	0.00	0.00	0.00	542.39
Industrial Gas	0.00	0.00	0.00	0.00	68.62	0.00	0.00	0.00	0.00	0.00	68.62
Electricity	1569.50	40.80	0.00	0.00	2460.83	2041.81	0.00	73.00	1068.70	148.92	7403.66
Non Energy	0.00	0.00	41.00	41.00	15.33	33.73	0.00	0.00	11.32	0.00	1526.00
Exportation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16528.10
Total Consumption	7465.57	23076.57	8434.52	9935.14	11143.18	4813.28	277.87	1299.08	3910.98	1697.61	89985.46

Table ES-1 Energy consumption for the base year 1990.

Model Used

The Energy and Power Evaluation Program (ENPEP) was used to accomplish this study. This model has been design to carry out power planification and enviromental studies of countries and regions. Its computer programm consists of nine technical modules: MACRO, DEMAND, BALANCE, ELECTRIC, ICARUS, LDC, MAED. PLANDATA and IMPACTS. Each module has automatic inputs and outputs to other modules as well as own capacities to carry out particular studies with them. In this study the modules: MACRO, DEMAND, BALANCE, ELECRIC and IMPACTS has been used. A mitigation study of the GHG requires the use of more than one module.

The ENPEP has been developed by the Argon National Laboratory (ANL) USA and was financed by the International Atomic Energy Agency (IAEA) which is responsible of its distribution and use. In the U.S Country Studies Program, many of the participating countries are using this model.

The ENPEP model requires a representation of the country energy system through an energy network. Figure ES-5 shows in a simple form the Peruvian Energy System and Apendix A shows the complete energy network used in the base scenario and in the mitigation options.

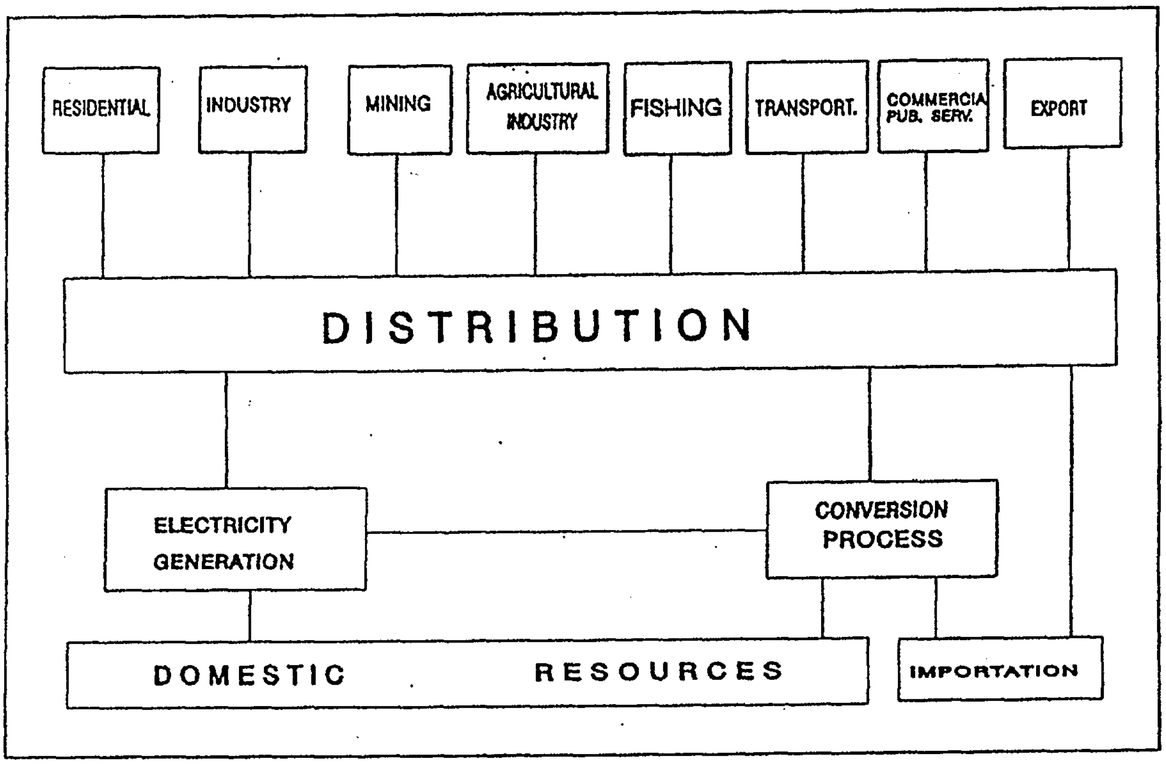

Fig. ES-3 Simple Peru's Energy Network.

Supply and Demand Energy Planning for the period between 1990 and 2015.

According to the ENPEP model and considering the macroeconomic scenario, the population statistics as well as the supply and demand energy of 1990, has been planning for the base scenario of the present study for the period between 1990 and 2015.

Figure ES-4 shows the total fuel consumption by all sectors, the main fuels used are: firewood, residual, diesel, gasoline and kerosene. Firewood is mainly used by the rural sector, the population use this fuel to cook their food. Because of its low efficiency, it requires great consumption quantities.

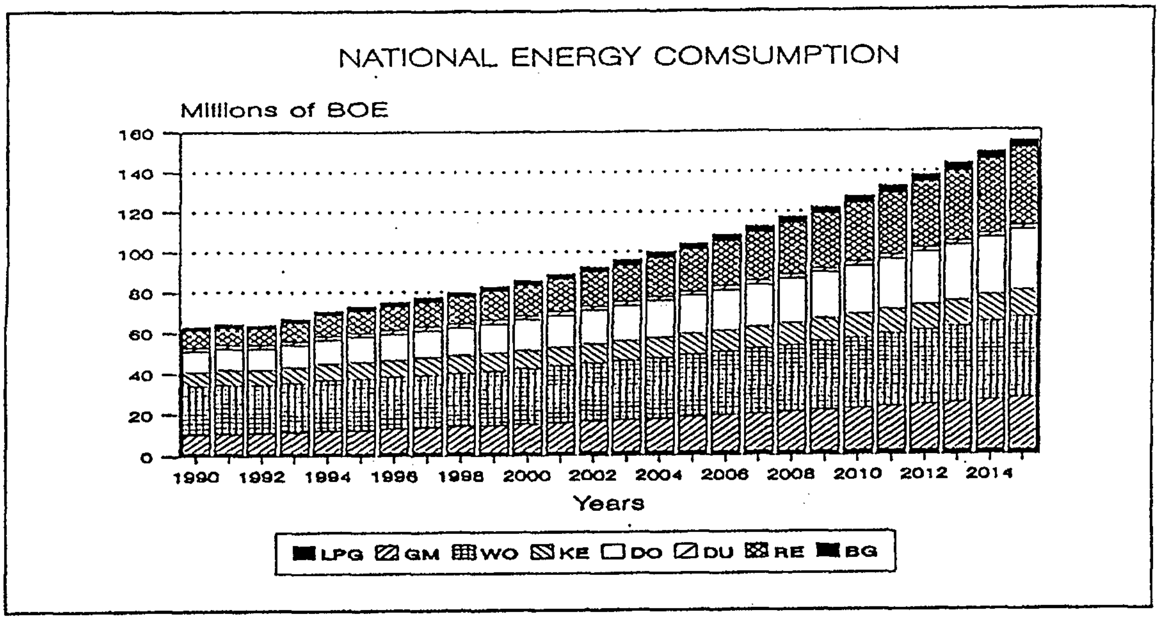

Fig. ES-4 Total energy requirement by sectors for the period in beetwen 1990-2015.

Figure ES-5 shows the total energy consumption by sectors for the base mitigation scenario. The sectors with major energy consumption are: Residential (Subsectors Urban and Rural) Industry and Transportation. The industrial sector has the major growth. This sector uses mainly woodfire mainly in food processing and bread making, that is why wood is the most important fuel in the total energy consumption.

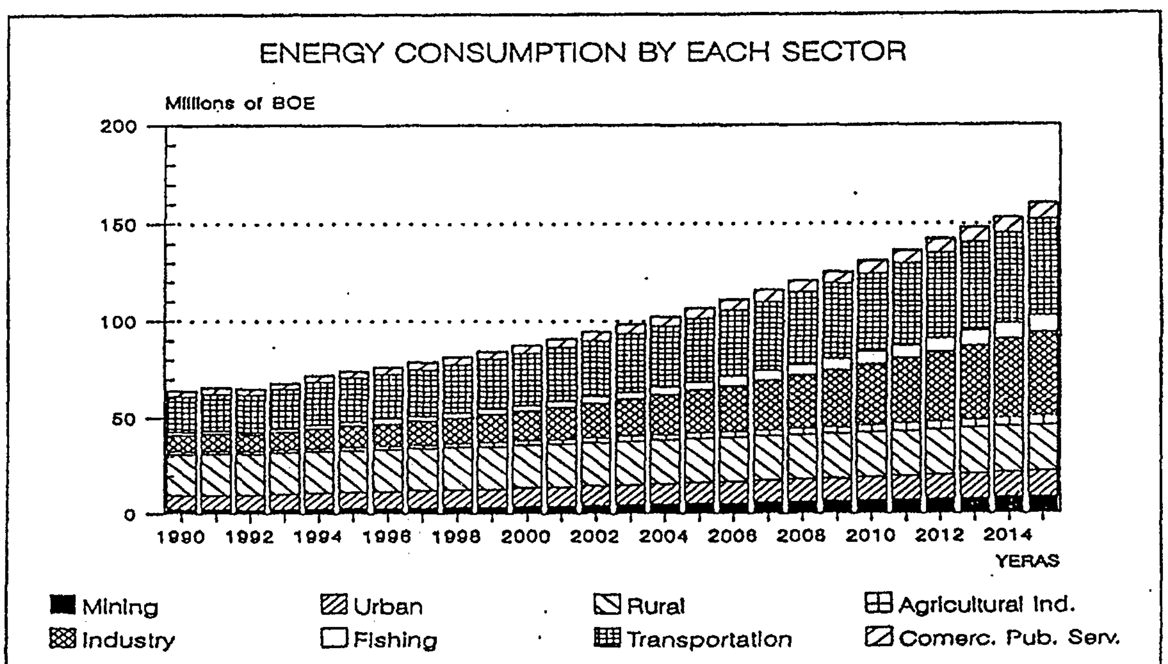

Fig. ES-5 Projected total energy consumption by each sector for the period in beetwen 1990 and 2015.

CO_2 Emissions for the mitigation base scenario

CO_2 emission for the mitigation base scenario has been obtained according to the foregoing premises and using the IMPACTS module of the ENPEP model.

The appraisal of CO_2 is based on the energy consumption for the whole energy system including the energy consupmtion used in the extraction of primary energy resources such as : crude oil, gas, coal; the production of secondary fuels through conversion process in refineries, coke plants, blast furnaces, charcoal plants and thermal power plants and the energy consumption in the demand sectors of Urban Residential, Rural Residential, Transportation, Industry, Mining, Commercial, Public Services, Fishing and Agricultural industry.

Table ES-2 shows CO_2 emissions for the demanding energy sectors, the conversion activity of primary Energy Resources into Secondary Fuels (referred to as own consumption and process) and the electricity generation for the mitigation base scenario of the Peruvian Energy Sector.

Taking into account the results of Greenhouse Gases, this study focuses only the mitigation study of CO_2 as the most important gas in the case of Perú.

Making a comparison between the CO_2 emissions obtained using the IPCC methodology for the base year (35.34 MMT) and the ENPEP model (35.76 MMT), a difference of 1.2% can be noted, this shows that the results and both methodologies are reliable, so the results of the present study are consistent.

According to the results showed in table ES-2, the CO_2 emissions in the Transportation Sector increase from 7.46 to 20.22 Million Metric Tonnes (MMT), in the Industry Sector it increase from 4.14 to 21.04 MMT, in the Urban Residential Subsector it increase from 2.68 to 4.63 MMT,in the Rural Residential Subsector it increase from 12.39 to 14.00 MMT and in the Electricity Generation activity it increase from 2.69 to 19.18 MMT.

CO_2 EMISSION FOR MITIGATION BASE SCENARIO
UNITS : Milllions of Tonnes

Años	Residential Rural	Residential Urban	Commerc. & Public	Transport	Agricult. Industry	Mining	Fishing	Industry	Process & Self. Cons.	Electrict. Generation	TOTAL
1990	12.39	2.68	1.25	7.46	0.77	1.21	0.66	4.14	2.50	2.69	35.76
1991	12.44	2.76	1.29	7.77	0.80	1.19	0.62	4.33	2.89	3.04	37.13
1992	12.49	2.84	1.27	7.86	0.77	1.15	0.55	4.00	2.87	2.96	36.76
1993	12.53	2.91	1.33	8.30	0.81	1.26	0.76	4.37	3.03	3.12	38.41
1994	12.58	2.99	1.46	8.93	0.89	1.41	0.86	4.94	3.27	3.35	40.68
1995	12.63	3.07	1.52	9.22	0.92	1.51	0.92	5.22	3.40	3.48	41.88
1996	12.70	3.15	1.58	9.51	0.96	1.61	0.87	5.54	3.53	3.48	42.94
1997	12.77	3.23	1.64	9.82	1.00	1.71	1.06	5.91	3.65	4.00	44.78
1998	12.85	3.30	1.70	10.14	1.03	1.81	1.14	6.31	3.78	5.04	47.11
1999	12.92	3.38	1.78	10.53	1.08	1.93	1.23	6.79	3.93	5.60	49.16
2000	13.00	3.46	1.85	10.94	1.13	2.05	1.32	7.31	4.09	6.49	51.62
2001	13.08	3.54	1.94	11.37	1.18	2.17	1.42	7.87	4.26	6.48	53.31
2002	13.17	3.62	2.02	11.82	1.23	2.30	1.53	8.49	4.44	7.11	55.72
2003	13.25	3.70	2.11	12.30	1.28	2.43	1.65	9.15	4.63	7.74	58.24
2004	13.33	3.77	2.20	12.81	1.34	2.57	1.78	9.86	4.83	8.56	61.05
2005	13.42	3.85	2.30	13.34	1.40	2.72	1.91	10.62	5.05	9.18	63.79
2006	13.47	3.93	2.40	13.91	1.47	2.87	2.05	11.44	5.27	9.93	66.74
2007	13.52	4.01	2.51	14.51	1.53	3.03	2.20	12.31	5.52	10.76	69.89
2008	13.57	4.09	2.63	15.15	1.60	3.20	2.36	13.24	5.77	11.69	73.29
2009	13.62	4.15	2.75	15.81	1.68	3.37	2.53	14.21	6.03	12.60	76.74
2010	13.67	4.24	2.87	16.49	1.75	3.55	2.70	15.23	6.32	13.55	80.37
2011	13.73	4.32	2.99	17.19	1.83	3.73	2.88	16.30	6.60	14.61	84.19
2012	13.80	4.40	3.12	17.92	1.91	3.92	3.07	17.42	6.90	15.65	88.10
2013	13.87	4.48	3.25	18.66	1.99	4.11	3.26	18.58	7.21	16.80	92.22
2014	13.93	4.55	3.39	19.43	2.08	4.31	3.46	19.79	7.53	17.94	96.40
2015	14.00	4.63	3.53	20.22	2.16	4.51	3.67	21.04	7.86	19.18	100.80

Table ES-2 CO_2 emision by demand sectors, own consumption by energy sector, conversion process and electricity generation for the base scenario.

Figure ES-6 shows the CO_2 emission by each sector for the mitigation base scenario. It can be noted that, the Rural, Transportation, Industrial sectors are the most important in the CO_2 emission as well as in the electricity generation.

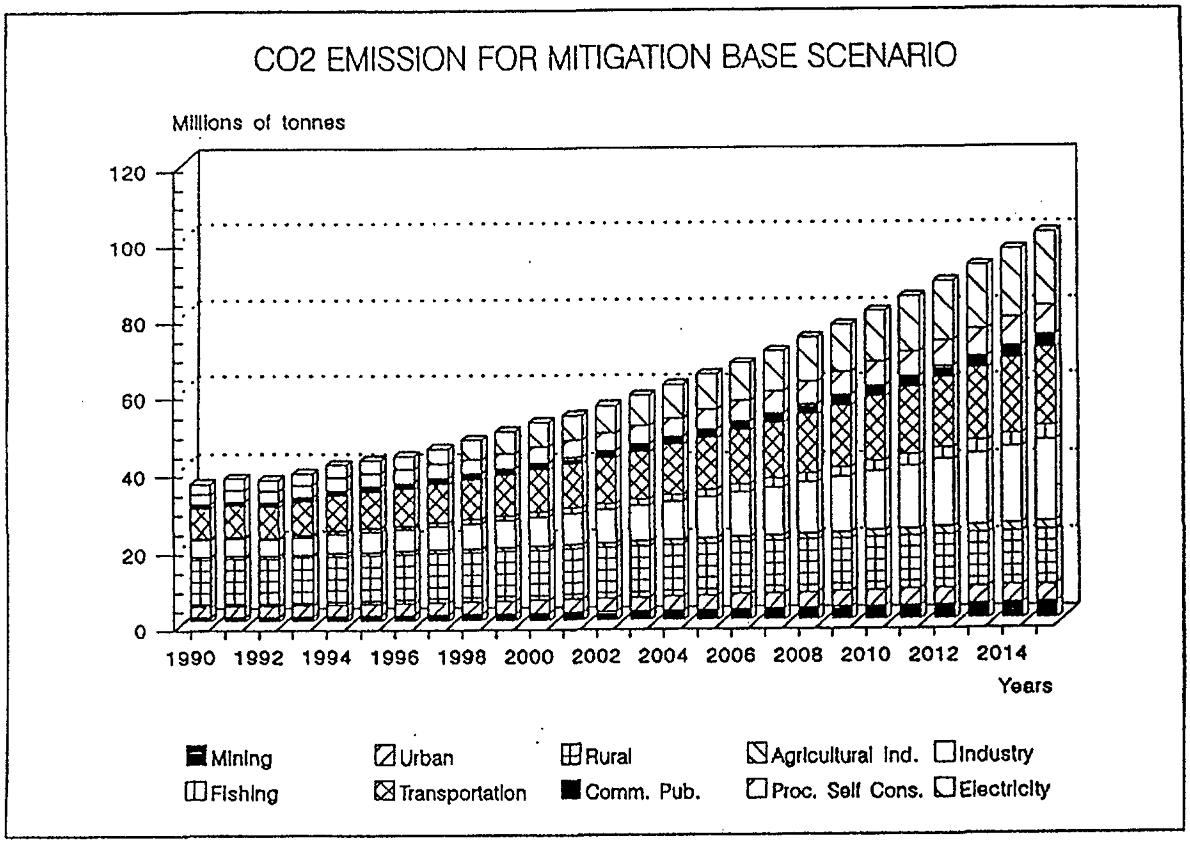

Fig. ES-6 CO_2 emission by each sector for the base scenario in beetwen 1990 and 2015.

MITIGATION SCENARIO

According to the inventory of Greenhouse Gases for 1990 and the mitigation base scenario, the most important sectors of energy consumption and CO_2 emission are the Residential Sector formed by : the Urban and Rural Residential Subsectors, Transportation and Industrial Sectors and by the Coversion Activity of Electricity Generation. For this reason, mitigation proposals for these sectors as well as in the Generation of Electricity have been carried out.

Table ES-3 shows the base scenario emissions (without mitigation) and the mitigation options for the Urban and Rural Residential subsectors, Transportation and Industrial Sectors as well as the electricity Generation by thermal power plants.

In the Urban Residential Subsector, it has been identified that the kerosine is the most used fuel, for this reason it has been proposed in the mitigation option that from 2001 the new kerosine demand will be substituted by natural gas and by liquified petroleum gas (LPG) asuming that in that year the Camisea gas will be available for use.

It is proposed for the Rural Residential Subsector, a wood substitution by LPG from 1999 in 2% for each year. This is with the aim to get a reduction of 20% of the use in 1998 in the year 2008. This assumption is based on the fact that, the population who run away from their lands because of the terrorism, will return to their homelands and will use LPG instead of firewood, because LPG offers a better performance, use facility and a better quality of life.

It is also convenient that the remaining 80% of wood consumption will be use more efficiently and with better cooks. For this purpose, it is necessary to carry out studies aimed at quantify the wood mitigation; up to now these studies has not been carry out.

In the transportation Sector the mitigation option contains the following assumptions:

a) The limit circulating time for automoviles must be 18 years and for buses and trucks 16 years.

b) For the year 2015, the automovile inventory must be constituted by the 20% of compressed natural gas vehicles,10% of buses,pick ups and small trucks. Tows and small gas tows has not been considered.

c) The vehicles which exceed the stipulated limit circulating time must to be replace or refixing using better maintenance in order to fullfil the stipulated regulations of the new ones.

d) The reference about the limit circulating time has been considered from the base year 1990, that is to say that, for the year 2008 the vehicles of 1990 must fullfil the control enviromental control regulations, if not they will be removed.

It is also necessary to implement new transportation modalities for Lima, such as the Electric Train. Although, it is also important to take into account the electrical energy origin, because ,if it is thermal there would be not GHG emission reduction. Another option is to replace Public transportation of small buses and rural vans by buses with great public capacity and also to apply a better transportation managment. These options will be studied after this project.

The following assumptions have been made in the Industrial sector:

a) The firewood consumption of the year 2000 must be reduce to 30% in the year 2015 replacing it by natural gas. This assumption taking into account that in that year Camisea gas will be under exploitation. This is possible due to the fact that, wood is used in bread industry and other activities relating to the direct heat generation.

b) The new technologies and industry modernization must be aimed in such manner that from the total growth of 2001, the increase of redisual will be only 1% for similar technologies; Technologie substitution which use gas will be 2% of the total growth and the remaining growth with residual new technology.

c) The proposed scenario for the use of residual oil is the same as the one proposed for the equipment that use Diesel fuel. This scenario is possible since it has been considered a better system maintenance and a moderated gas change as well as a deep economic analysis for its implementattion (for example pipeline gas building and new machinery buying)

The Electric Plan has been made using the Wien Automatic System Planning Package (WASP). This model has also been used in the electricity generation activity. For this study two scenarios has been considered: the base scenario and the mitigation scenario. In the first case, the electric plan was elaborated without considering the Camisea gas and using the alternative plants of the Ministry of Energy and Mines. In the second case (mitigation scenario), it was elaborated considering the plants technologie by combinated gas cycle asuming in that way that the camisea gas will be under exploitation from 2000.

CO_2 EMISSION BY SECTORS WITH MITIGATION 1990 - 2015

UNITS : Millions of Tonnes

Years	Rural Residencial		Urban Residencial		Transportation		Industry		Electric Generation	
	Without Mitig.	With Mitig.	Without Mitig.	With Mitig.	Without Mitig.	With Mitig.	Without Mitig.	With Mitig.	Without Mitig.	With Mitig.
1990	12.39	12.39	2.68	2.68	7.46	7.46	4.14	4.14	2.69	2.69
1991	12.44	12.44	2.76	2.76	7.77	7.77	4.33	4.33	3.04	3.04
1992	12.49	12.49	2.84	2.84	7.86	7.86	4.00	4.00	2.96	2.96
1993	12.53	12.53	2.91	2.91	8.30	8.30	4.37	4.37	3.12	3.12
1994	12.58	12.58	2.99	2.99	8.93	8.93	4.94	4.94	3.35	3.35
1995	12.63	12.63	3.07	3.07	9.22	9.22	5.22	5.22	3.48	3.48
1996	12.70	12.70	3.15	3.15	9.51	9.24	5.54	5.54	3.48	3.48
1997	12.77	12.78	3.23	3.23	9.82	9.20	5.91	5.91	4.00	4.00
1998	12.85	12.85	3.30	3.30	10.14	9.27	6.31	6.31	5.04	5.04
1999	12.92	12.68	3.38	3.38	10.53	9.41	6.79	6.79	5.60	5.58
2000	13.00	12.51	3.46	3.46	10.94	9.56	7.31	7.31	6.49	5.81
2001	13.08	12.35	3.54	3.52	11.37	9.73	7.87	7.58	6.48	5.83
2002	13.17	12.18	3.62	3.58	11.82	9.92	8.49	7.85	7.11	6.16
2003	13.25	12.02	3.70	3.64	12.30	10.13	9.15	8.16	7.74	6.65
2004	13.33	11.85	3.77	3.71	12.81	10.37	9.86	8.51	8.56	7.38
2005	13.42	11.69	3.85	3.77	13.34	10.63	10.62	8.89	9.18	7.83
2006	13.47	11.51	3.93	3.83	13.91	11.02	11.44	9.31	9.93	8.19
2007	13.52	11.34	4.01	3.89	14.51	11.43	12.31	9.75	10.76	8.93
2008	13.57	11.17	4.09	3.95	15.15	11.87	13.24	10.24	11.69	9.74
2009	13.62	11.18	4.15	4.00	15.81	12.34	14.21	10.75	12.60	10.40
2010	13.67	11.19	4.24	4.07	16.49	12.83	15.23	11.29	13.55	11.11
2011	13.73	11.21	4.32	4.13	17.19	13.33	16.30	11.87	14.61	11.88
2012	13.80	11.27	4.40	4.19	17.92	13.86	17.42	12.47	15.65	12.69
2013	13.87	11.26	4.48	4.25	18.66	14.40	18.58	13.10	16.80	13.64
2014	13.93	11.26	4.55	4.31	19.43	14.97	19.79	13.77	17.94	14.71
2015	14.00	11.28	4.63	4.47	20.22	15.55	21.04	14.46	19.18	15.85
TOTAL	342.73	311.43	95.05	93.08	331.41	278.57	264.41	216.86	225.03	193.54

Table ES-3 Emissions with and without mitigation for the urban and rural subsectors, Industrial and Transportation sectors as well as electricity generation activity.

Table ES-3 shows that in the Rural Residential Subsector, the CO_2 emission without mitigation increases from 12.39 to 14.00 MMT and with mitigation it decreases from 12.39 to 11.28 MMT. As a result of this, in 2015 a reduction of 2.7 MMT of CO_2 and a total reduction of 31.3 MMT during the whole period (1990-2015) are achieved.

In the Urban Residential Subsector, the CO_2 emission without mitigation increases from 2.68 to 4.6 MMT and with mitigation it increases from 2.68 to 4.37 MMT, as a result of this in 2015 a reduction of 0.3 MMT and a total reduction of 1.97 MMT during the whole period (1990-2015) are achieved.

In the Transportation Sector, the CO_2 emission without mitigation increases from 7.46 to 20.22 MMT and with mitigation it increases from 7.46 to 15.55 MMT, as a result of this, in 2015 a reduction of 7.46 MMT and a total reduction of 52.28 MMT during the whole period (1990-2015) achieved.

In the Industrial Sector, the CO_2 emission without mitigation increases from 7.14 to 21.04 MMT and with mitigation it increases from 7.14 to 14.46 MMT, as a result of this in 2015 a reduction of 6.6 MMT and a total reduction of 47.55 MMT during the whole period (1990-2015)are obtained.

In the Electricity Generation Activity, the CO_2 emisssion without mitigation increases from 2.69 to 19.18 MMT and with mitigation it increases from 2.69 to 15.85 MMT, as a result of this a reduction of 3.3 MMT and a total reduction of 31.49 during the whole period (1990-2015) are achieved.

TOTAL CO_2 MITIGATION

The total CO_2 mitigation for the energy sector is summarized in table ES-4 and ES-8. Table ES-4 shows the total CO_2 emission for the base and mitigation scenario. Table ES-7 shows the results of the mitigation proposal for the present study.

In the base case scenario, the CO_2 emission increases from 35.76 in 1990 to 100.80 MMT in 2015. In the mitigation scenario, it increases from 35.76 to 83.24 MMT respectively, as a result of this in 2015 a total reduction of 17.76 MMMT of CO_2 (17.4%) is achieved.

CO_2 TOTAL EMISSIONS
UNITS : MILLIONS OF TONNES

Years	Without Mitigation	With Mitigation
1990	35.76	35.76
1991	37.13	37.08
1992	36.76	36.72
1993	38.41	38.31
1994	40.68	40.49
1995	41.88	41.66
1996	42.94	42.66
1997	44.78	44.15
1998	47.11	46.24
1999	49.16	47.77
2000	51.62	49.08
2001	53.31	49.98
2002	55.72	51.20
2003	58.24	52.70
2004	61.05	54.54
2005	63.79	56.18
2006	66.74	57.91
2007	69.89	60.14
2008	73.29	62.53
2009	76.74	65.03
2010	80.37	67.68
2011	84.19	70.46
2012	88.10	73.40
2013	92.22	76.48
2014	96.40	79.78
2015	100.80	83.24

Table ES-4 CO_2 total emission for the base and mitigation scenarios.

Figure ES-8 shows the total emission with and without mitigation for the whole time of the project (1990-2015) as well as the total CO_2 reduction for the mitigation scenario. A total reduction of 165 MMT of CO_2 is obtained. For Peru, this is an important factor that will contribute to resolve the earth warming problem, taking into account that the proposed scenario is moderated in the application of the mitigation measures.

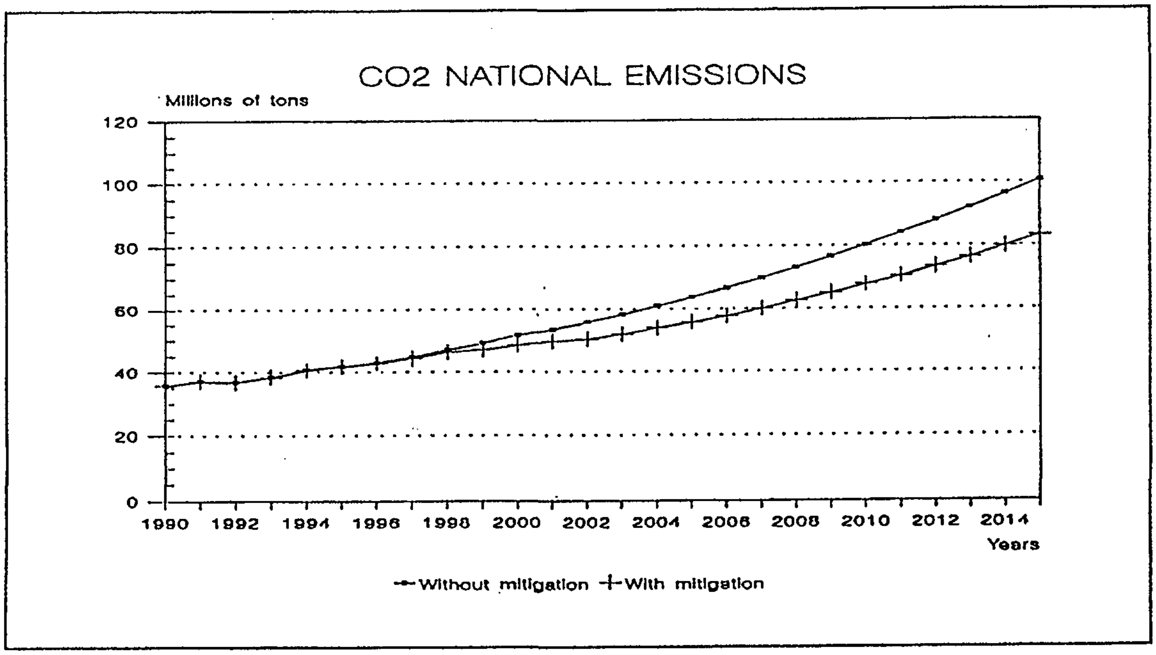

Fig. ES-7 Total CO_2 emission with and without mitigation for the energy sector in between 1990 and 2015.

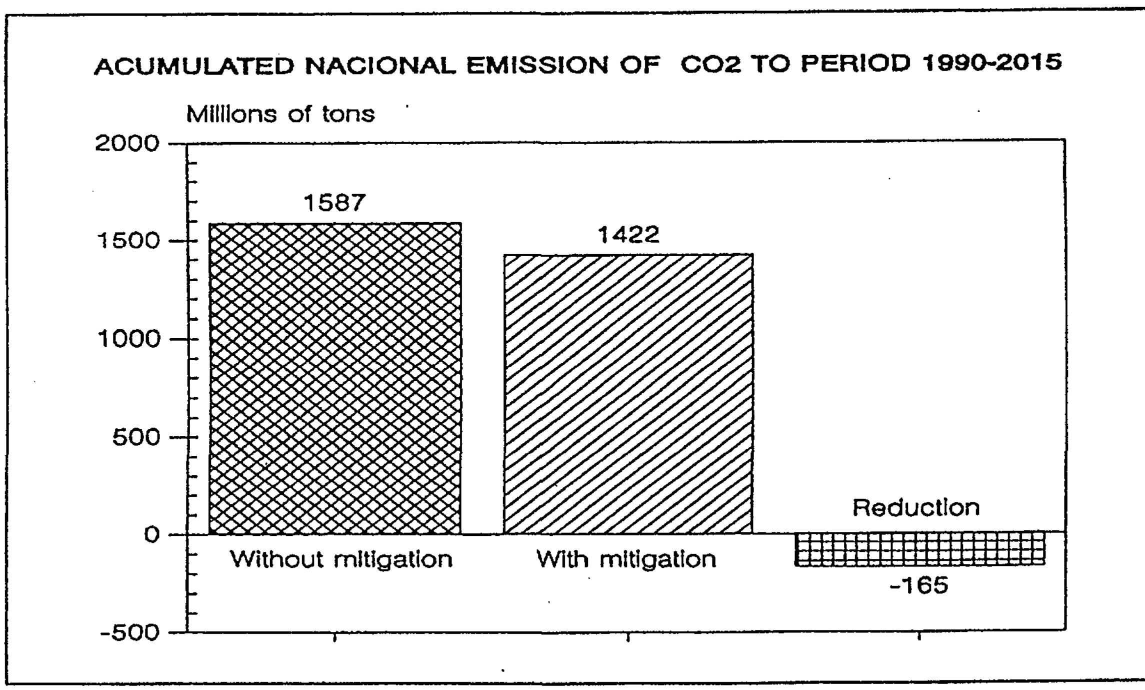

Fig. ES-8 Total CO_2 emission with and without mitigation for the whole period of study (1990-2015).

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I. ENERGY SECTOR

INTRODUCTION

One important challenge at the end of 20th century is to achieve an equitative world-wide development with low pollution rates, avoiding in this way unexpected and fatal changes. Perú conscious of this situation has signed international Agreements aimed at the preservation of the environment.

Nowadays, Perú is in process of development, the Public sector is being reorganized and privatized. The increase rate of GNP is high and it is expected that it will keep in that train. The consequences of this increase at middle term, implies a growing deforestation of the Amazonic region and air pollution in the most important cities with great industrial zones such as Lima. The expected increase rates will lead to a continued energy resources consumption and emission of Green House Gases.

It is also duty to consider that, even though the necessity of a balanced economic development and environmental quality is recognized, the measures to do so has not been established up to now. Although the reorganization and the current economic reform represents opportunities to make Institutional and Political reforms aimed at a fast development and a better management of the environment, taking into account the Agreement of Change Environmental Structure signed in Río de Janeiro in the frame of the Convention about Climate Change of the United Nations Organization.

The present study shows a quantitative and qualitative analysis for the implementation of GHG mitigation measures. The first part presents the calculation of future stages of GHG emission for a base scenario. The second one shows GHG mitigation alternatives for the following sectors: Industrial, Residential and Electricity Production. The Energy and Power Evaluation Program ENPEP links the economic growth to demand energy estimates and generates and balanced scenario for the supply and demand of energy, given in this way future energy supply alternatives. The model predicts also, the GHG emission levels which are specification for crucial decisions such as: government policies, technologies availability, energy supply, energy demand priorities or priorities that are not affected by supply costs.

This study was made jointly with the Peruvian Institute of Nuclear Energy (IPEN), the National University of Engineering (UNI) (Faculty of Enviromental Engineering) and the National Service of Hydrology and Meteorology (SENAMHI). The Argon National Laboratory(ANL) has given technical assistance to the ENPEP model implementation..

I.1 MITIGATION BASE SCENARIO

The base mitigation scenario has been elaborated in order to quantify the GHG emission reduction. This scenario is used as a reference to evaluate cost/profit of mitigation options. The computer program ENPEP- made by the Argon National Laboratory (ANL)- has been used in this study with the sponsorship of the International Atomic Agency (IAEA).

I.1.1 PERU ENERGY SITUATION

The worldwide situation about energy requirement is well known. Its demand is going to continue at the same time as the countries look for a better standard of life. For this reason, the energy is a basic service for the population and requires great efforts to optimize its use, exploitation and transformation, avoiding or reducing the pollution. To this aim, its is necessary that each country use energy policies to ensure its development and be part of the worldwide environmental consensus which leads to an apparent and whole evaluation of the country energy system. This evaluation includes the actualization of data about energy resources reserves and its demand as well as technologies required for their transformation, exploitation, transport and use.

Peru Energy consumption has been historically irregular with high and low consumption increases. This variation is due to the different policy changes made by the different governments and other natural factors such as the "Corriente del niño" in 1983 and 1992. The Hydrocarbon fuels have been the most used.

Nowadays, Peru has enough finite energy resources to support its development, among these we have:natural gas, oil, uranium, coal.

Table I.1.1 shows the proved and probable reserves for 1990 . Among the renewable energy resources, Hydroenergy is the most important for electricity production. Energy resources such as solar, eolic, geothermal and biomass seem to be economically convenient for the future. Among the Peruvian main energy resources we have:

NON RENEWABLE RESOURCES

CRUDE OIL

Crude oil is a non renewable resource which has priority in our country. There is not big proved reserves to satisfy a great development in the future; for this reason the ruling government is promoting local and foreign companies investments for the exploration of this resource. Peru has two kinds of crude oil: light crude oil in the coast and heavy crude oil in the Jungle; for this reason Peru exports crude oil and heavy residual and at the same time imports light products to fulfill in an adequate form the demand of derived products.

GAS

Natural gas is the hydrocarbon which Peru has in great sizeable reserves, however its consumption is low because of the lack of studies and agreements for its exploitation. The main gas field is in Cuzco (Camisea) in the South west of Peru. From the geographic viewpoint it is far from the main consumption centers such as Lima. Recently, Peru has signed and agreement with Shell and Mobil aimed at the exploitation of the Camisea gas.

COAL

Coal is a resource which reserves have not been examined in detail. There are studies that shows that the existing kind of coal is the anthracite which has a great content of sulfur. Due to this sulfur content, its exploitation is not appropriate. Today the great part of coal used by Peru is imported.

RENEWABLE RESOURCES

HYDROENERGY

The hydric resource is one of the most important in the country. It is used specially for electricity production accounting 75% of the total generation. There are studies relatively detailed about the great potential of this resource. However, its use is restricted because of the necessity of great inversions for its exploitation and for the energy transmission to consumption centers which are far from the production plants. In the coast basin, the hydric resource is used in great percentage (80%).[4]

It is also important to consider that this resource depends on climate conditions such as the "corriente del niño" (for example in 1992) which cause up to the 34% of the electric consumption restriction because of the rain lack in the highlands.

The studies about the use of this resource , which goes to the Atlantic Ocean, shows that it is expensive. Today, the Peruvian economic situation makes difficult to carry out its exploitation. It is worthly to consider that, it has been started a building program of hydroelectric small plants.

WOOD

Wood is very important in our country.Its use accounts 32% of the total energy consumption of the base year. The rural Population and Urban population use wood for meeting cook necessities, nevertheless the urban population use wood in low rates. This aspect makes evident that other fuels are not available or are so expensive to obtain by these population. According to the results of this study, it is proposed that the government implements an effective energy policy for the Rural Sector and part of the Urban Population.

DUNG

Dung as wood is used by the Rural Population to meet cook necessities.

BAGASSE

Bagasse is used, as a non energy product, for paper manufacturing as well as for other products and in minor scale for electric energy production.

SOLAR ENERGY

Solar energy is used mainly in departments of the highlands to dry food, heat water and in minor scale to produce energy. There are no projects about mass use or great scale electricity production. There are, in different universities, a lot of small application and researching projects about solar energy use.

EOLIC ENERGY

Eolic energy is used to produce electricity. In some places of the coast, it is used as mechanical energy. There are no important projects about the eolic energy use. It is necessary to make a national evaluation of its potential.

GEOTHERMAL ENERGY

In Peru the geothermal energy is at preliminary studies level . As it is known, there is a small potential of this resource in the south part of the country. Although there is no a study about its quantification.

PROVED AND POBABLE RESERVERS

RESOURCES	PROVED	PROBABLE
CRUDE OIL	386.6 MBls	743 MBls
NATURAL GAS	7 E+12 FC	Not identified
COAL	70 MTM	131.9 MTM
URANIUM	10000 TM	25000 TM
HYDROENERGY	10000 KTOE	364000 KTOE
WOOD	720 MTOE	

Table I.1.1 Proved and probable energy reserves for 1990 [2].

I.1.2 THE ENERGY IN THE BASE YEAR

The energy situation for the base year can be observed in the Energy Balance of 1990, which is based on the National Energy Balance and have been elaborated by the National Energy Council (CONERG) of the Ministry of Energy and Mines (MEM).

The sales made to the local market reported by PETROPERU as well as the data provided by ministries, national companies, private industries and services companies makes possible to verify and up date the data of the Energy Balance of 1990 [7,3].

GENERAL STRUCTURE

The up dated Energy Balance 1990 has the same structure as the National Balance made by CONERG. The following definitions has been used in the general structure of the Energy Balance:

Primary Energy.- Are the different energy products in its natural form. For the case of the Peruvian balance , these products are: hydroenergy, natural associated and non associated gas, crude oil, dung, wood and coal.

Transformation.- Is the process by which the primary energy resources are transformed into secondary energy resources. Among the main transformation process we have: thermal electric plants, coke plants, charcoal plants, oil refineries and gas plants.

Secondary energy products.- Are the different energy products which are appropriate for the different forms of consumption. It's origin is always a transformation center and its destination a consumption center. For the case of the Peruvian Energy Balance, we have the following secondary products: coke, charcoal, licuated petroleum gas, motor gasoline, jet, diesel oil, residual oil, gas, gas from refineries, distributed gas, industrial gas and energy power.

Consumption.- Is the process by which the secondary energy products are used according to specific ways of use. It is one of the great functions of the Energy Balance.
For the Peruvian case we have the following consumption sectors: Commercial-Residential, Agriculture Cattle and Agricultural Industry, Transportation, Industrial, Mining-Metallurgy and Fishing.

The Energy Balance 1990 for this study is shown in table I.1.2, it has a vertical division that separates the Primary Energy Sector, the Secondary Energy Sector, the Total Primary Energy (TOTAL EP, column 8), the Total Secondary Energy (TOTAL SE, column 21), the Total Energy (TOTAL, column 22) and the fuel names. In the horizontal division we have the Production Identification (row 1), Importation (row 2) and Inventories Variation (row 3). In the following rows we have, the Total Offer (row 4), Export (row 5), Non used Energy (row 6), Gross Internal Offer (row 7), Total Transformation (row 8), Own Energy Consumption (row 9), Transportation Lost, Distribution and Storage (row 10), Adjustments (row 11), Total and Final Consumption (row 12) which contains non Energy final consumption (row 12.1) and finally the Energy Consumption (12.2). The Final Energy Consumption is divided in the following sectors: Commercial. Residential (row 12.2.1), Public (row 12.2.2), Transportation (row 12.2.3), Agriculture Cattle and Agricultural Industry (row 12.2.4), Fishing (row 12,2.5), Mining and Metallurgy (12.2.6), Industrial (row 12.2.7) and Non identified Consumption (row 12.2.8).

The data referred to as adjustments are statistical tools which have been used to comply the offer and consumption data from the different information resources. Likewise, the quantities in parenthesis has been used as primary resources for the production of secondary resources such as: oil, coal , wood, bagase, natural gas, hydroenergy and coke.

UNIT : THOUSAND OF BCE (kBCE) — ACTUALIZED ENERGY BALANCE - 1990 — YEAR : 1990

REPUBLIC OF PERU / PERU CLIMATE CHANGE COUNTRY STUDY / PCS-IPEN / SIE	PRIMARY ENERGY								SECONDARY ENERGY													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	COAL	WOOD	DUNG	BAGASS	CRUDE OIL	ASSOC. NAT. GAS	HYDRO ENERGY	TOTAL P. E.	COKE	CHARC	LPG	MOTOR GASOLIN	JET KEROSE	DIESEL OIL	RESID. OIL	NON EN OIL/GAS	REFIN GAS	DIS. GAS	IND. GAS	ELECTR. POWER	TOTAL S. E.	TOTAL
1. PRODUCTION	498.3	25,665.5	1,894.3	2,311.2	47,397.9	5,528.6	8,218.9	91,514.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	91,514.6
2. IMPORT	218.0	0.0	0.0	0.0	6,481.5	0.0	0.0	6,699.5	301.3	0.0	461.4	266.4	515.6	3,796.8	0.0	138.6	0.0	0.0	0.0	0.0	5,480.1	12,179.6
3. STOCK CHANGE	47.4	0.0	0.0	0.0	(601.2)	0.0	0.0	(553.9)	0.0	0.0	21.2	(7.2)	55.3	(41.7)	123.5	(12.9)	(5.4)	0.0	0.0	0.0	132.8	(421.1)
4. TOTAL OFFER	763.6	25,665.5	1,894.3	2,311.2	53,278.2	5,528.6	8,218.9	97,660.2	301.3	0.0	482.6	259.2	570.9	3,755.1	123.5	125.7	(5.4)	0.0	0.0	0.0	5,612.9	103,273.1
5. EXPORT	0.0	0.0	0.0	0.0	(1,091.5)	0.0	0.0	(1,091.5)	0.0	0.0	0.0	(531.5)	0.0	(81.6)	(14,823.3)	0.0	0.0	0.0	0.0	0.0	(15,436.6)	(16,528.1)
6. NOT USED	0.0	0.0	0.0	0.0	0.0	(1,351.1)	0.0	(1,351.1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	(1,351.1)
7. GROSS INTERNAL OFFER	763.6	25,665.5	1,894.3	2,311.2	52,186.7	4,177.5	8,218.9	95,217.7	301.3	0.0	482.6	(272.3)	570.9	3,673.3	(14,699.8)	125.7	(5.4)	0.0	0.0	0.0	(9,823.7)	85,393.9
C. 8. TOTAL TRANSFORMATION	(190.1)	(2,260.7)	0.0	(332.2)	(54,251.5)	(3,743.6)	(8,218.9)	(68,997.0)	(82.9)	904.3	1,089.0	9,531.0	7,508.1	5,576.5	24,085.6	493.7	501.0	2,755.9	150.5	8,668.1	61,180.9	(7,816.1)
8.1 COKE PLANT/BLAST FURNA	(190.1)	0.0	0.0	0.0	0.0	0.0	0.0	(190.1)	(82.9)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	150.5	0.0	67.5	(122.6)
8.2 CHARCOAL PLANTS	0.0	(2,260.7)	0.0	0.0	0.0	0.0	0.0	(2,260.7)	0.0	904.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	904.3	(1,356.4)
8.3 REFINERIES	0.0	0.0	0.0	0.0	(54,251.5)	0.0	0.0	(54,251.5)	0.0	0.0	1,020.3	9,330.1	7,508.1	8,641.8	26,568.4	323.8	501.0	0.0	0.0	0.0	53,893.5	(358.0)
8.4 GAS PLANTS	0.0	0.0	0.0	0.0	0.0	(3,743.6)	0.0	(3,743.6)	0.0	0.0	68.7	200.9	0.0	0.0	0.0	170.0	0.0	3,304.1	0.0	0.0	3,743.6	0.0
8.5 P.S. ELECTRIC POWER PLA	0.0	0.0	0.0	0.0	0.0	0.0	(6,881.9)	(6,881.9)	0.0	0.0	0.0	0.0	0.0	(1,360.0)	(532.2)	0.0	0.0	0.0	0.0	5,994.0	4,101.9	(2,780.1)
8.6 S.P. ELECTRIC POWER PLA	0.0	0.0	0.0	(332.2)	0.0	0.0	(1,337.0)	(1,669.2)	0.0	0.0	0.0	0.0	0.0	(1,705.3)	(1,950.6)	0.0	0.0	(548.2)	0.0	2,674.1	(1,529.9)	(3,199.1)
9. SELF CONSUMPTION	0.0	0.0	0.0	0.0	(0.0)	0.0	0.0	(0.0)	0.0	0.0	0.0	(25.6)	(19.0)	(562.8)	(584.7)	0.0	(501.0)	(2,535.9)	(50.7)	(87.8)	(4,367.5)	(4,367.5)
10.LOSSES(TRANS.DIST. STOR.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	(1,177.2)	(1,177.2)	(1,177.2)
11. AJUSTEMENTS	(108.0)	0.0	0.0	0.4	2,064.8	(433.9)	0.0	1,523.3	(22.4)	0.2	(193.4)	(182.6)	(961.7)	1,257.8	(130.5)	(32.6)	5.4	322.3	(31.1)	0.0	30.7	1,554.2
12. TOTAL FINAL CONSUMPTIO	465.6	23,404.7	1,894.3	1,979.4	0.0	0.0	0.0	27,744.0	195.9	904.5	1,378.2	9,050.5	7,098.4	9,944.8	8,670.6	586.8	0.0	542.4	68.6	7,403.7	45,843.9	73,587.8
12.1 NON ENENRGY FINAL CONSUMPTION				1,082.7				1,082.7					7.6			443.3					450.9	1,533.6
12.2 ENERGY FINAL CONSUMP	465.6	23,404.7	1,894.3	896.7	0.0	0.0	0.0	26,661.3	195.9	904.5	1,378.2	9,050.5	7,090.8	9,944.8	8,670.6	143.5	0.0	542.4	68.6	7,403.7	45,393.5	72,054.8
12.2.1 RESIDENTIAL/COMMERC	54.2	20,159.1	1,894.3	0.0	0.0	0.0	0.0	22,107.6	0.0	904.5	1,362.9	0.0	4,987.7	0.0	0.0	0.0	0.0	335.1	0.0	2,679.1	10,269.2	32,376.8
12.2.2 PUBLIC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	538.7	443.4	917.6	165.2	11.3	0.0	0.0	0.0	0.0	2,076.3	2,076.3
12.2.3 TRANSPORT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8,383.3	1,614.5	7,557.0	732.9	82.0	0.0	0.0	0.0	0.0	18,369.7	18,369.7
12.2.4 AGROPECULTURE/AGRI	0.0	0.0	0.0	896.7	0.0	0.0	0.0	896.7	0.0	0.0	0.0	19.0	1.5	135.8	495.8	0.5	0.0	0.0	0.0	148.9	801.4	1,698.1
12.2.5 FISHING	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	291.3	1,210.5	0.5	0.0	0.0	0.0	73.0	1,577.5	1,577.5
12.2.6 MINING METALLURGICAL	57.3	0.0	0.0	0.0	0.0	0.0	0.0	57.3	195.9	0.0	15.3	82.9	33.6	368.7	1,984.1	33.7	0.0	0.0	0.0	2,041.8	4,756.0	4,813.2
12.2.7 INDUSTRY	354.1	3,245.7	0.0	0.0	0.0	0.0	0.0	3,599.7	0.0	0.0	0.0	24.5	10.2	674.5	4,062.1	15.4	0.0	207.3	68.6	2,460.8	7,543.5	11,143.2
12.2.8 NON IDENTIFIED CONSU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	9	10	11	12	13	14	15	16	17	18	19	20	21
GROSS SECONDARY ENENRGY PRODUCTION	168.0	904.3	1,089.0	9,530.7	7,508.1	8,841.8	26,609.9	1,576.4	501.0	3,304.1	150.5	8,674.3	68,658.2

PRODUCTION OF COQUE = 168.0 + BLAST FURNACE ENTR (251.1) = (83.1)

ELABORATION : PCS Energy Sector
SOURCE : MEM AND PETROPERU S.A.

Table 1.1.2 National Balance of Energy 1990 [7].

I.1.3 MACROECONOMIC SCENARIO

I.1.3.1 Gross Domestic Product

Peruvian macroeconomy has been irregular with respect to the Gross Domestic Product (GDP) as it is shown in table I.1.3 and in figure I.1.1. Peruvian GDP has changed according to the growth of the Peruvian working force, and liberal and social governmental policies has had a great influence in this growth.

Table I.1.3 shows the GDP in soles of 1979 [8] for the period between 1980 and 1993, it also includes the economic activities developing in the following sectors: Transportation, Industrial, Mining, Fishing, Agriculture Cattle and Agricultural Industry, and Public Service.

Figure I.1.1 shows the Total GDP for the period of the table I.1.3 in which we can note the irregularity of the total GDP which has been nearly the same as in the economic sectors. The GDP percentage structure by areas for the period between 1980 and 1990 is shown in picture I.1.2. It is observed that in the Peruvian economic structure between 1980 and 1990 it does not present great changes.

I.1.3.2 Estimated Gross Domestic Product (GDP)

A time series model was used to forecast total and sectorial GDP and in that way stablish the forecasted macroeconomic scenario. The model is represented by the polynomial function: I.1.1 [9]

$$Y(t) = a_0 + a_1 + a_2 t^2 + a_3 + a_4 t^4$$

where:

$y(t)$ = total and sectorial GNP
t = government periods
a_1, a_2, a_3 = adjustment parameters

The equation I.1.1 has been used to estimate the total and sectorial GDP of the main country economic sectors such as : Industrial, Mining, Agriculture, Commercial and Transportation. These are shown in table I.1.4 [9].

HISTORIC GDP (1980 - 1993)
(Millions of nuevos soles refered to 1990 year)

YEARS	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993/1
TRANSPORT SECTOR	439.6	466.3	450.9	406.6	397.1	407.8	436.0	476.2	430.8	362.4	342.8	357.0	360.9	381.2
Freight /3	231.6	244.6	236.4	213.6	208.0	213.3	228.7	249.9	225.6	189.8	179.5	187.0	189.0	--
Passengers /3	208.0	221.6	214.5	193.0	189.1	194.5	207.4	226.3	204.9	172.6	163.2	170.0	171.9	--
INDUSTRY SECTOR	1339.2	1341.4	1309.4	1039.7	1109.1	1166.5	1320.2	1511.9	1314.1	1110.9	1031.9	1080.4	996.7	1319.4
Industry Textil and hide	292.8	273.3	262.8	225.4	245.0	272.2	296.2	312.7	314.3	290.2	247.7	240.6	209.5	--
Industry Wood and furniture	82.7	82.9	88.8	72.5	75.8	78.4	93.6	98.4	88.5	83.7	76.9	76.8	68.2	--
Industry of paper	108.0	111.8	97.2	90.4	89.6	83.5	96.2	113.0	112.6	64.5	76.0	57.1	34.5	--
Industry Chemistry	209.4	223.0	224.1	165.9	183.0	169.5	233.5	274.0	237.4	171.2	167.8	173.9	169.0	--
Manufacture of non metalic p	76.1	81.0	78.7	69.5	66.7	66.7	90.6	125.4	119.8	78.9	77.4	61.1	83.0	--
Ind. of Metalic basics	338.6	320.9	333.4	295.6	322.2	341.4	325.1	324.2	255.6	309.0	266.5	323.7	328.6	--
Manuf. of Prod. Metalics	195.4	212.5	191.2	96.4	102.4	113.5	157.8	227.4	153.7	93.1	96.3	104.1	76.4	--
Manuf. of others products	36.3	36.0	33.2	24.0	24.5	21.2	27.3	36.7	32.1	20.2	21.4	23.1	25.3	--
Milling and bakery	67.4	79.0	80.0	80.4	91.0	79.7	85.6	98.0	92.2	75.1	65.6	77.5	77.3	--
Beberage and Tabacco	157.5	154.7	155.1	156.1	141.9	155.2	214.9	235.7	186.3	139.9	132.1	146.1	133.2	--
MINING SECTOR	981.1	950.9	962.6	868.1	909.6	948.7	906.2	879.2	747.4	711.0	649.2	633.8	613.7	671.4
Oil Extraction	611.6	593.5	597.0	503.9	534.2	541.9	509.9	471.9	410.8	372.6	331.9	296.6	298.6	325.5
Minerals Extraction	369.5	357.4	365.6	364.2	375.4	406.8	396.3	407.3	336.6	338.4	317.3	337.2	315.1	345.9
FISHING SECTOR	111.7	107.9	121.7	57.6	100.6	115.2	152.1	130.6	156.8	173.9	176.7	167.0	148.4	204.8
Fish Extraction	39.5	43.1	50.6	35.6	52.0	60.9	80.5	70.9	84.0	88.4	87.8	77.8	74.0	102.2
Fish Manufacture	39.1	30.3	22.5	18.0	34.9	32.8	38.0	29.7	44.8	55.3	62.4	60.0	44.9	--
Flour and oil of Fish	33.0	34.5	48.6	4.1	13.7	21.5	33.6	30.1	28.0	30.2	26.5	29.2	29.5	--
COMMERCIAL SECTOR	2551.6	2735.1	2723.2	2351.8	2420.1	2461.8	2704.8	2966.0	2639.6	2284.8	2198.2	2301.5	2272.4	2381.5
Commercial	1106.6	1176.5	1169.9	958.8	979.0	987.0	1137.0	1248.6	1118.6	934.9	918.5	972.8	965.6	--
Financial	205.7	225.3	239.8	244.0	239.7	276.4	272.6	292.0	288.4	266.4	268.5	274.6	276.1	--
Assurances	22.3	22.9	16.5	12.5	12.9	16.5	21.8	23.1	12.2	14.6	15.8	17.7	16.6	--
Houses rent	185.4	189.7	193.0	195.1	197.8	199.5	205.4	212.5	212.7	214.7	216.8	218.3	219.3	--
Services to Interprises	394.7	422.5	409.9	367.6	369.0	396.0	437.6	485.0	412.4	398.2	386.5	404.7	406.1	--
Restaurants anh Hotels	262.0	265.9	272.7	275.9	286.2	305.6	336.6	372.2	324.4	277.8	260.0	270.2	250.0	--
Serv. a Hog. Mercants	174.5	185.2	182.9	170.7	174.9	182.4	196.4	207.6	184.9	158.5	118.0	120.2	114.6	--
Serv. a Hog. no Mercants	68.7	70.4	73.6	77.9	80.8	82.6	85.8	90.8	83.1	77.7	76.0	79.7	77.7	--
Health Private	64.7	67.5	66.2	66.7	73.3	74.5	79.2	81.7	75.7	69.7	60.2	59.0	55.9	--
Education Private	26.3	27.4	28.2	28.2	30.1	32.4	33.6	35.0	34.5	34.0	34.2	34.9	35.7	--
Comision Imputed	-172.3	-187.0	-188.8	-206.0	-185.0	-232.7	-262.1	-268.3	-261.9	-247.7	-251.7	-256.4	-259.1	--
Fee of Importation	213.0	268.8	259.3	158.5	161.4	141.6	159.0	183.5	154.4	85.9	95.5	105.4	113.7	--
AGRICULT./AGRIC. IND. SECTO	937.2	1014.4	1035.6	943.9	1014.3	1044.1	1099.7	1188.2	1257.8	1157.8	1090.5	1114.2	1066.3	1125.0
Agricult. hunt and forestry	759.1	827.7	846.0	764.5	842.7	867.3	904.9	964.5	1032.8	974.9	907.3	926.7	875.5	--
Manufacture of milky product	21.0	21.8	22.3	20.8	19.3	19.4	20.3	23.9	23.0	19.3	18.7	21.5	20.2	--
Manufacture of sugar	20.0	17.9	21.6	15.7	21.4	25.6	21.0	19.5	20.0	20.8	19.6	19.1	15.8	--
Other foood products	137.1	147.0	145.7	142.9	130.9	131.9	153.6	180.3	182.0	142.7	144.9	146.9	154.9	--
PUBLIC SECTOR	1048.6	1120.7	1148.8	1075.0	1131.6	1102.0	1252.9	1378.5	1299.5	1161.0	1102.9	1078.5	1075.2	880.9
Public Health	47.7	49.9	51.1	52.8	57.7	65.3	68.1	66.7	65.2	53.4	46.9	43.1	36.0	36.0
Public Education	183.4	190.9	199.5	207.9	219.7	226.2	230.9	248.6	195.6	165.7	145.6	133.9	133.9	134.1
Others governmentals Serv.	258.1	261.1	255.5	279.4	303.8	292.7	334.1	347.9	343.0	299.0	262.7	241.7	241.7	241.9
Electricity and water	81.7	87.6	94.8	79.6	79.9	84.6	99.7	107.4	108.0	106.6	107.0	120.4	106.6	--
Comunications /2	54.1	60.2	67.6	75.2	87.2	90.0	103.5	117.3	130.4	146.3	138.3	144.1	145.7	--
Construction	423.4	471.0	480.4	380.3	383.4	343.2	416.6	490.5	457.3	390.2	402.5	395.3	411.3	468.9
GDP TOTAL	7633.8	7970.4	7987.2	6979.3	7315.4	7481.1	8172.4	8864.2	8124.4	7176.9	6789.9	6956.0	6744.0	7216.6

/1 Estimated
/2 Since of 1990 year it has calculate according its partipation in the previous year.
-- There is not data.
/3 It has been esimated in base of its participation in the previous year.
SOURCE : INEI and BCR

Table I.1.3 Gross Domestic Product by sectors, in nuevos soles, base year 1990 [8]

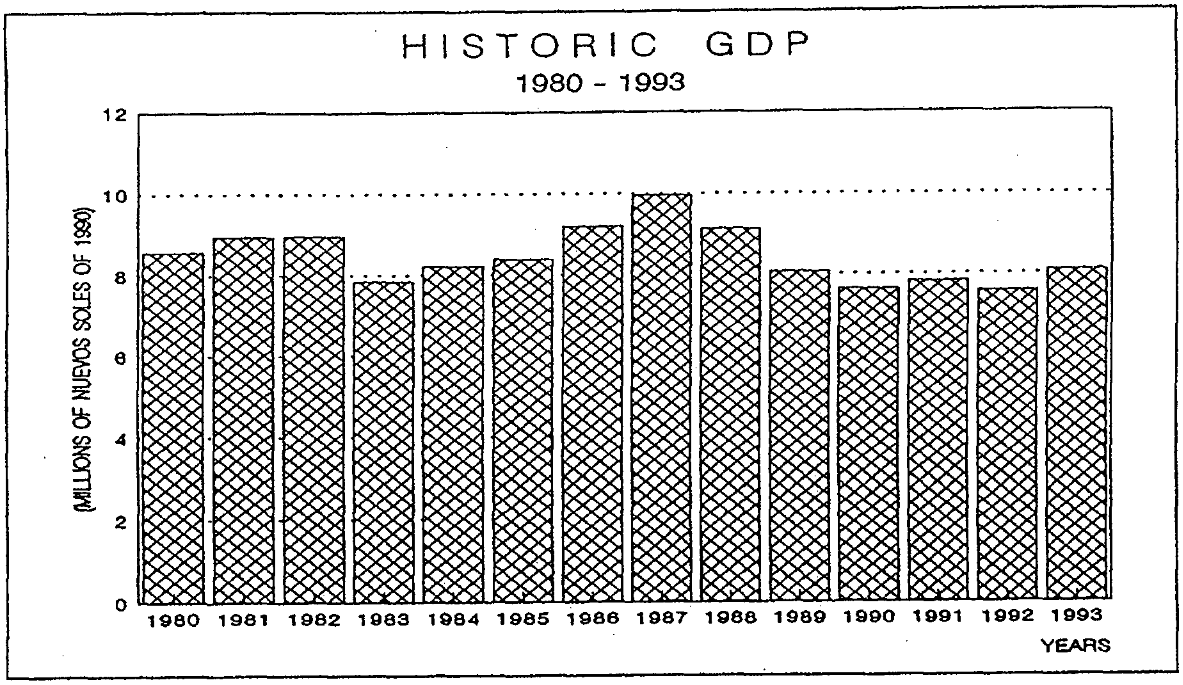

Fig. I.1.1 Historical evolution of the peruvian total GDP for the period in between 1980-1993 [8].

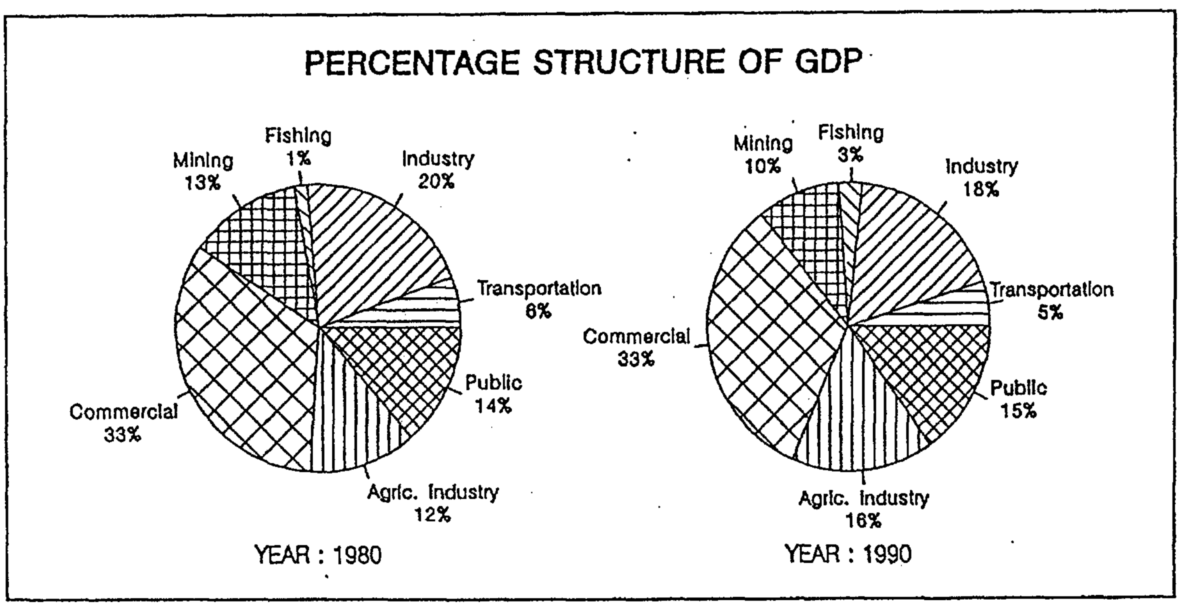

Fig. I.1.2 Percentage structure of peruvian GDP of 1980-1990.

The macroeconomic scenario shows the current governmental free market policies as well as the activities carried out by the governmentin order to promote foreign investments in the country. The economic stabilization, in an annual inflation rate of almost 12%, allows an economic growth of 7.4% in 1993, 10.7% in 1994, 7.0% in 1995 and it is expected that since 1996 this rate will be between 3% and 5%.

The president reelection ensures the continuing development of the current governmental policies which predict an economic growth with a starting annual rate of 4.5% and after its stabilization at long term, it presents an average rate of 3.5%.

TOTAL AND SECTORIAL PROJECTED GROSS DOMESTIC PRODUCT
UNITS : MILLIONS OF NUEVOS SOLES OF 1990

Years	AGRICULTURE		FISHING		MINING		INDUSTRY		TRANSPORT.		COMMERCIAL & PUBLIC		BUILDING		TOTAL	
	Quantity	(%)	Quantity	(%)	Quantity	(%)	Quantity	(%)	Quantity	(%)	Quantity	(%)	Quantity	(%)	Quantity	(%)
1990	1288.2	0.0	176.7	0.0	649.2	0.0	1031.9	0.0	342.8	0.0	2898.6	0.0	402.5	0.0	6789.9	0.0
1991	1337.8	3.8	167.0	-5.5	633:8	-2.4	1080.4	4.7	357.0	4.1	2984.7	3.0	395.3	-1.8	6956.0	2.4
1992	1276.8	-4.6	148.4	-11.1	613.7	-3.2	996.7	-7.8	360.9	1.1	2945.7	-1.3	411.3	4.1	6753.4	-2.9
1993	1347.0	5.5	204.8	38.0	671.4	9.4	1089.4	9.3	381.2	5.6	3087.1	4.8	468.9	14.0	7249.6	7.3
1994	1473.7	9.4	231.4	13.0	755.2	12.5	1230.5	13.0	410.4	7.7	3383.4	9.6	540.6	15.3	8025.3	10.7
1995	1533.2	4.0	247.6	7.0	806.5	6.8	1301.4	5.8	423.6	3.2	3519.0	4.0	595.3	10.1	8426.6	5.0
1996	1594.2	4.0	265.4	7.2	859.0	6.5	1382.2	6.2	437.2	3.2	3657.8	3.9	652.1	9.5	8847.9	5.0
1997	1657.0	3.9	284.7	7.3	912.9	6.3	1473.0	6.6	451.4	3.2	3800.4	3.9	711.0	9.0	9290.3	5.0
1998	1722.0	3.9	305.5	7.3	968.1	6.1	1573.8	6.8	466.2	3.3	3947.5	3.9	771.8	8.6	9754.9	5.0
1999	1797.8	4.4	329.5	7.9	1029.7	6.4	1692.6	7.5	484.0	3.8	4119.4	4.4	838.4	8.6	10291.4	5.5
2000	1877.0	4.4	355.3	7.8	1093.6	6.2	1822.6	7.7	502.7	3.9	4298.7	4.4	907.5	8.2	10857.4	5.5
2001	1959.9	4.4	383.0	7.8	1160.0	6.1	1964.0	7.8	522.4	3.9	4486.2	4.4	979.1	7.9	11454.5	5.5
2002	2046.8	4.4	412.6	7.7	1229.0	5.9	2117.0	7.8	543.3	4.0	4682.6	4.4	1053.2	7.6	12084.5	5.5
2003	2138.0	4.5	444.2	7.7	1300.8	5.8	2282.1	7.8	565.4	4.1	4888.8	4.4	1129.9	7.3	12749.2	5.5
2004	2233.9	4.5	477.8	7.6	1375.7	5.8	2459.6	7.8	588.7	4.1	5105.3	4.4	1209.4	7.0	13450.4	5.5
2005	2334.8	4.5	513.6	7.5	1453.9	5.7	2649.8	7.7	613.4	4.2	5333.0	4.5	1291.7	6.8	14190.1	5.5
2006	2441.0	4.5	551.6	7.4	1535.7	5.6	2853.3	7.7	639.6	4.3	5572.6	4.5	1376.9	6.6	14970.6	5.5
2007	2552.9	4.6	591.9	7.3	1621.2	5.6	3070.7	7.6	667.2	4.3	5824.9	4.5	1465.2	6.4	15794.1	5.5
2008	2670.8	4.6	634.8	7.2	1710.8	5.5	3302.5	7.5	696.5	4.4	6090.7	4.6	1556.6	6.2	16662.7	5.5
2009	2792.4	4.6	679.5	7.0	1802.9	5.4	3546.1	7.4	728.9	4.4	6364.8	4.5	1649.9	6.0	17562.5	5.4
2010	2917.8	4.5	726.2	6.9	1897.7	5.3	3801.4	7.2	758.2	4.3	6647.3	4.4	1744.8	5.8	18483.3	5.3
2011	3046.9	4.4	774.8	6.7	1995.0	5.1	4068.4	7.0	790.6	4.3	6938.0	4.4	1842.3	5.6	19456.0	5.2
2012	3179.7	4.4	825.3	6.5	2095.0	5.0	4347.0	6.8	824.0	4.2	7237.0	4.3	1939.2	5.3	20447.1	5.1
2013	3316.3	4.3	877.7	6.4	2197.4	4.9	4637.2	6.7	858.4	4.2	7544.1	4.2	2051.2	5.8	21482.3	5.1
2014	3456.4	4.2	932.1	6.2	2302.4	4.8	4938.9	6.5	893.8	4.1	7859.3	4.2	2138.6	4.3	22521.5	4.8
2015	3600.1	4.2	988.2	6.0	2409.9	4.7	5251.9	6.3	930.1	4.1	8182.4	4.1	2239.8	4.7	23602.6	4.8

Tabla I.1.4 Total and sectorial GDP projected in nuevos soles of 1990.

1.1.4 NATIONAL POPULATION STATISTICS

Population data have been obtained from the National Institute of Statistics and Informatics [11]. According to the analysis of this data, we can assert that the Peruvian population shows a substantial growth in the last two decades characterized by the inequality of its distribution, composition and concentration; it also shows an important and fast urbanization process.

According to the Population and Housing Census of 1940, 1961, 1972, 1981, 1993 we can distinguish four census periods which show the Peruvian population growth. Therefore in the period between 1940 and 1946, a 2.2% of the internal growth rate has been obtained, this rate has increased to 2.9% between 1961 and 1972 and has decreased to 2.6% and 2.2% between 1981 and 1993 as it is shown in table I.1.5.

According to table I.1.5 the Urban Population had a growth rate higher than the rural population. Then, we can realize that during the period between 1940 and 1993, the national population has had an annual growth of 2.55%, meanwhile the Urban Population grew in 3.8% and the Rural only in 0.09%. This fact was due to the people migration to the city whose growth has been positive but changeable during the last years.

EVALUACION DEL CRECIMIENTO POBLACIONAL PERUANO

YEARS PERIODS	URBAN	RURAL	TOTAL
1940 - 1961	3.7	1.2	2.2
1961 - 1972	5.0	0.5	2.9
1972 - 1981	3.6	0.8	2.6
1981 - 1993	2.8	0.9	2.2
1940 - 1993	3.8	0.9	2.5

FUENTE : INEI, CENSO NACIONAL DE VIVIENDA Y POBLACION

Table I.1.5 Population growth rate by periods [10]

Peruvian Population is distributed in 23 departments . In 1990, the Urban Population was 15,550,205 (70.3%) and at the same time the Rural Population was 6,393,057 (29.7%), both populations gives a total Population of 21,550,122. The Population distribution by departments for 1990 is shown in table I.1.6.

I.1.4.1 Growth of the population for 1990 - 2015.

Table I.1.7 Shows the population total projection for the period 1990 - 2015. Tables I.1.8 and I.1.9 show the projections by departments for the urban and rural populations.

The population projection has been obtained by using INEI methodologies. It is expected a stabilization of both popualtion in growth rates of about 2.0 % (urban population) and).2 % (rural population) reaching in this way a average rate of 1.6 % and a national population of 336345556 inhabitants for 2015.

PERUVIAN POPULATION IN 1990
(Inhabitants)

Departments	Total	Urban	%	Rural	%
Amazonas	320516	116027	36.2	204453	63.8
Ancash	953926	553515	58.0	400353	42.0
Apurimac	373031	126893	34.0	246104	66.0
Arequipa	904225	776042	85.8	128097	14.2
Ayacucho	506999	235490	46.4	271463	53.6
Cajamarca	1216651	301598	24.8	915028	75.2
Callao	624374	623418	99.8	856	0.2
Cusco	1005725	467206	46.5	538473	53.5
Huancavelica	379931	102325	26.9	277579	73.1
Huanuco	619515	236163	38.1	383314	61.9
Ica	555309	462260	83.2	92966	16.8
Junin	1026200	672592	65.5	353542	34.5
La Libertad	1241036	854549	68.9	386418	31.1
Lambayeque	892153	695494	78.0	196581	22.0
Lima	6298555	6092132	96.7	206326	3.3
Loreto	653438	381393	58.4	271987	41.6
Madre de Dios	58913	33566	57.0	25290	43.0
Moquegua	127568	105123	82.4	22363	17.6
Pasco	231407	138910	60.0	92437	40.0
Piura	1377206	960535	69.7	416601	30.3
Puno	1053695	408160	38.7	645496	61.3
San Martin	504638	309850	61.4	194727	38.6
Tacna	207970	185858	89.4	22023	10.6
Tumbes	147872	127889	86.5	19897	13.5
Ucayali	271028	185277	68.4	85683	31.6
Total Republic	21551883	15152265	70.3	6398057	29.7

Table I.1.6 Rural and Urban population estimated by departments [10].

URBAN AND RURAL POPULATION PROJECTED FOR 1990-2015

YEARS	URBAN	%	RURAL	%	TOTAL	%
1990	15,152,265		6,398,057		21,550,322	
1991	15,565,206	2.73	6,433,052	0.55	21,998,258	2.08
1992	15,989,402	2.73	6,464,467	0.49	22,453,869	2.07
1993	16,425,156	2.73	6,490,716	0.41	22,915,872	2.06
1994	16,872,787	2.73	6,510,223	0.30	23,383,010	2.04
1995	17,332,616	2.73	6,521,401	0.17	23,854,017	2.01
1996	17,757,423	2.45	6,573,281	0.80	24,330,704	2.00
1997	18,192,648	2.45	6,621,267	0.73	24,813,915	1.99
1998	18,638,532	2.45	6,662,396	0.62	25,300,928	1.96
1999	19,095,350	2.45	6,693,683	0.47	25,789,033	1.93
2000	19,563,362	2.45	6,712,142	0.28	26,275,504	1.89
2001	19,985,914	2.16	6,775,798	0.95	26,761,712	1.85
2002	20,417,591	2.16	6,831,878	0.83	27,249,469	1.82
2003	20,858,592	2.16	6,878,132	0.68	27,736,724	1.79
2004	21,309,122	2.16	6,912,308	0.50	28,221,430	1.75
2005	21,769,375	2.16	6,932,165	0.29	28,701,540	1.70
2006	22,195,495	1.96	6,960,473	0.41	29,155,968	1.58
2007	22,629,959	1.96	6,987,633	0.39	29,617,592	1.58
2008	23,072,923	1.96	7,013,602	0.37	30,086,525	1.58
2009	23,524,561	1.96	7,038,322	0.35	30,562,883	1.58
2010	23,985,037	1.96	7,061,745	0.33	31,046,782	1.58
2011	24,460,206	1.98	7,086,762	0.35	31,546,968	1.61
2012	24,946,806	1.99	7,108,863	0.31	32,055,669	1.61
2013	25,445,184	2.00	7,127,870	0.27	32,573,054	1.61
2014	25,955,699	2.01	7,143,582	0.22	33,099,281	1.62
2015	26,478,730	2.02	7,155,826	0.17	33,634,556	1.62

Table I.1.7 Urban and Rural population projected for the period between 1990-2015 [12].

TOTAL URBAN POPULATION PROJECTED FOR 1990-2015

(Thousands)

AÑOS	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Republica	15152	15567	15991	16426	16873	17334	17758	18194	18640	19098	19563	19987	20419	20859	21310	21769	22193	22630	23073	23523	23985	24393	24814	25242	25682	26125
Departamentos																										
Amazonas	116	120	123	127	131	135	139	143	147	151	155	159	163	167	171	175	179	183	187	191	195	199	203	207	211	215
Ancash	554	563	573	583	593	603	612	621	630	639	648	656	663	671	678	686	692	699	705	711	717	722	727	731	736	740
Apurimac	127	132	137	142	148	154	159	165	171	177	184	190	196	202	209	216	222	229	236	243	251	258	265	272	280	287
Arequipa	776	795	814	834	854	875	893	912	931	950	969	986	1004	1021	1039	1057	1073	1089	1106	1123	1139	1153	1168	1182	1197	1212
Ayacucho	235	241	246	251	256	262	266	270	275	279	284	288	292	296	300	304	307	310	314	317	321	323	326	329	332	334
Cajamarca	302	311	321	331	341	352	362	373	383	395	406	416	427	438	449	461	471	482	494	505	517	527	538	549	560	572
Callao	623	642	661	681	701	722	742	763	784	806	828	849	870	891	913	935	956	977	999	1021	1044	1064	1085	1106	1128	1150
Cuzco	467	479	490	502	514	526	538	549	561	574	586	597	608	619	631	642	653	663	674	685	696	705	714	724	734	743
Huancavelica	102	104	105	106	108	109	110	111	112	113	114	115	115	116	116	117	117	118	118	118	119	119	119	119	119	119
Huanuco	236	247	257	269	281	293	305	318	331	344	359	372	387	401	416	432	448	464	480	497	515	532	549	567	586	605
Ica	462	475	488	501	514	526	540	552	565	578	591	602	614	626	638	651	662	673	685	696	708	718	729	739	750	761
Junin	673	688	704	720	737	754	769	784	799	815	831	845	859	873	887	901	914	927	940	953	967	978	989	1000	1011	1023
La Libertad	855	877	900	924	948	973	995	1018	1041	1065	1089	1110	1132	1154	1176	1199	1220	1241	1262	1284	1305	1324	1343	1363	1382	1402
Lambayeque	695	714	733	752	771	792	809	827	845	863	881	898	915	931	949	966	982	998	1014	1030	1046	1060	1075	1089	1104	1118
Lima	6092	6245	6402	6562	6726	6893	7044	7197	7354	7513	7675	7818	7964	8111	8260	8412	8548	8687	8827	8968	9111	9233	9357	9482	9609	9738
Loreto	381	395	409	424	439	455	471	487	504	521	538	555	572	590	608	626	644	663	681	701	720	739	758	777	797	818
Madre de Dios	34	36	39	41	44	47	51	55	59	63	68	73	78	83	89	95	102	109	116	124	133	141	150	160	171	182
Moquegua	105	108	110	113	116	119	122	124	127	130	132	135	137	140	143	145	147	150	152	155	157	159	161	164	166	168
Pasco	139	140	141	142	143	144	144	145	145	146	146	146	145	146	146	146	146	146	145	145	145	144	143	143	142	141
Piura	961	986	1013	1040	1068	1096	1124	1152	1180	1209	1239	1266	1293	1321	1350	1379	1405	1432	1460	1487	1516	1541	1566	1592	1618	1644
Puno	408	422	436	450	465	480	494	509	524	540	556	571	586	602	618	634	650	666	682	698	715	730	746	762	779	795
San Martín	310	325	342	359	377	396	415	436	458	480	504	528	552	578	604	632	660	689	720	751	784	816	850	885	921	959
Tacna	186	193	201	208	216	225	233	241	250	259	268	277	286	296	306	316	325	335	345	356	367	377	387	398	409	420
Tumbes	128	133	139	145	151	157	163	170	177	184	191	198	205	212	220	228	235	243	251	260	268	277	285	294	303	312
Ucayali	185	196	207	219	231	244	258	272	287	304	321	337	355	374	394	414	435	457	480	504	529	554	581	608	637	667

Table I.1.8 Urban population projected by deparments for 1990 - 2015 period [12]

TOTAL RURAL POPULATION PROJECTED FOR 1990 - 2015
(Thousands)

Años	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
República	6396	6434	6465	6492	6507	6522	6574	6621	6662	6491	6713	6776	6832	6879	6912	6932	6958	6988	7017	7039	7062	7088	7110	7129	7143	7156
Departamentos																										
Amazonas	204	208	211	214	216	219	222	226	229	232	235	239	243	246	249	252	255	257	260	263	265	268	270	273	275	277
Ancash	400	401	401	400	399	398	398	399	398	398	396	397	397	397	396	394	392	391	389	387	385	383	381	379	376	373
Apurimac	246	246	245	244	243	242	242	242	242	241	240	240	240	240	239	237	236	235	234	232	231	229	228	226	224	223
Arequipa	128	128	129	129	129	128	129	129	129	129	128	129	129	129	129	128	128	128	127	127	126	126	125	124	124	123
Ayacucho	271	265	259	252	246	239	234	229	224	219	213	209	205	200	195	190	185	181	176	171	167	162	158	153	149	145
Cajamarca	915	923	929	936	940	944	954	963	972	978	983	994	1004	1012	1019	1023	1028	1033	1038	1043	1047	1051	1054	1057	1059	1061
Callao	0.86	0.72	0.61	0.52	0.44	0.37	0.32	0.28	0.24	0.21	0.18	0.16	0.14	0.12	0.1	0.09	0.08	0.07	0.06	0.05	0.04	0.04	0.03	0.03	0.02	0.02
Cuzco	538	542	546	549	552	553	558	563	568	271	573	579	584	589	592	594	596	598	601	602	604	606	607	608	609	609
Huancavelica	278	279	279	280	280	280	281	282	283	383	283	284	285	286	286	286	286	285	285	284	284	283	282	281	280	279
Huanuco	383	388	392	396	400	403	409	414	420	424	428	435	441	446	451	455	459	463	467	471	474	478	482	485	488	490
Ica	93	93	92	92	91	91	91	90	90	90	89	89	89	88	88	87	87	86	85	85	84	83	83	82	81	80
Junin	354	353	353	352	351	350	350	350	350	349	348	349	349	349	348	346	345	343	342	340	339	337	335	333	330	328
La Libertad	386	389	392	394	395	396	400	403	405	407	409	412	416	418	420	421	422	424	425	426	426	427	428	428	428	428
Lambayeque	197	201	205	209	212	216	221	226	231	235	240	246	251	257	262	266	271	276	281	286	291	296	300	305	310	314
Lima	206	206	205	204	203	202	202	202	201	200	199	199	199	198	197	196	195	194	193	191	190	189	187	186	184	182
Loreto	272	276	281	285	288	292	297	302	306	311	314	320	326	331	335	339	343	347	351	355	359	363	367	370	374	377
Madre de Dios	25	26	27	28	29	30	32	33	34	35	37	38	40	42	43	45	46	48	50	52	53	55	57	59	61	63
Moquegua	22	22	22	22	22	21	21	21	21	21	20	20	20	20	20	19	19	19	19	19	18	18	18	18	17	17
Pasco	92	92	92	92	91	91	91	91	91	90	90	90	90	90	89	89	88	88	88	87	86	86	85	85	84	83
Piura	417	413	410	406	401	397	394	392	389	385	381	379	377	374	371	366	362	358	354	350	346	342	337	333	328	324
Puno	645	647	648	648	647	646	649	651	653	653	652	656	658	660	660	659	658	658	657	655	654	653	651	649	646	643
San Martín	195	201	207	214	220	226	235	243	251	259	267	277	287	297	306	315	325	335	345	355	365	376	387	398	408	419
Tacna	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	21
Tumbes	20	20	19	19	19	18	18	18	17	17	17	17	16	16	16	16	15	15	15	14	14	14	14	13	13	13
Ucayali	86	92	98	104	111	118	124	130	136	142	149	156	164	172	179	187	195	204	213	222	232	241	252	262	273	284

Table I.1.9 Rural population projected by departments for 1990 - 2015 period [12]

I.1.5 METHODOLOGY FOR THE BASE MITIGATION SCENARIO

The applied methodology for this scenario is based on the technical information provided in the mitigation workshop carried out in the Lawrence Berkeley Laboratory (LBL)- USA .This methodology is aimed to quantify the GHG emissions from energy resources extraction to its end use considering their different transformations in a probable developing base scenario.

The Energy and Power Evaluation model (ENPEP) was used to carry out this study, which has been developed to accomplish environmental and planning studies and is composed of nine technical modules, each one with automatic inputs and outputs to other modules as well as own capacities to carry out particular studies with them. In this study we have used the following modules: MACRO, DEMAND, BALANCE, ELECRIC and IMPACTS. It is necessary to use more than one module for a GHG mitigation study.

The ENPEP model requires energy supply data , transformation technologies and energy demand for the base year. The model estimates the energy demand for the period of study based on the economic and energy scenarios pre-established by the users, according to the population growth and macroeconomic variabilities.

The IMPACT module makes possible the quantification of the base scenario GHG emissions for the energy and as well as associated costs.

I.1.5.1 Energy and Power Evaluation Program (ENPEP)

The ENPEP model was developed by the Argon National Laboratory (ANL) and cofinanced by the International atomic Energy Agency (IAEA) responsible of its use and distribution.

Each module and the way of use of the ENPEP model are described concisely in the following pages.

The MACRO module was used to format to the macroeconomic GDP and population growth scenarios for the DEMAND module inputs. The MACRO module is not an instrument for economical planning plan but a tool to format the macroeconomic results (carry out externally) into a structure that could be transfer to other ENPEP modules.
The macroeconomic projections of this study were acquired from the Ministry of Economy and Finances which projection model was described in section I.1.3.2.

The DEMAND module translates the macroeconomic growth rates of the MACRO module into future energy demand projections. These projections can be produced from the final energy demand (natural gas, oil, gasoline) or from the useful energy demand (heating,power, steam steam). We focus the projection of useful energy demand with the aim to design, in an appropriate form, the mitigations options in final use sectors including energy efficiency improvements, fuel change and demand management. It is important to consider that, the option about the projection of useful energy instead of final energy depends on the demand data availability and on the technology characteristics. Sometimes it is difficult for the user to find this kind of information, for that reason the user can only use the final energy demand. We evaluate such energy system configuration by using the BALANCE model. This configuration achieves an equilibrium between offer and energy demand.

The BALANCE module uses an iterative non lineal method to determine the offer and energy demand balance. This module requires a design of the energy network to make possible that the energy flow outline from the primary resources to useful energy demand in end use sectors. Figure I.1.3 shows the Peruvian energy network. The full energy network is shown in Appendix A.

The BALANCE module is one of the most important of the ENPEP model. It is used to predict the offer and energy demand balances and uses a market algorithm by which is possible to distinguish between the focus and other design technics. It predicts precisely the behavior of complex market in which people make decisions.On the contrary, other optimization technics which can not easily predicts the behavior of the people complex market, because they are assume that the decisions are taken by one person only.

In the energy system, the Electric, Industrial and Residential sectors have different goals and a different view of what is optimum. For this reason, the model develops an energy system configuration which establish an equilibrium between demands and market forces without reaching an economic optimization. The economic optimization is determined by analysts according to their pre-established scenarios.

The electric system expansion was made using the ELECTRIC module. This expansion corresponds to the assumptions made for the whole energy system development in the base scenario.

The ELECTRIC module is the version for a PC of the Wien Automatic System Planning Package (WASP). This model allows the user to make an expansion plan of the electric system which face the electric demand growth taking into account the specifications and restrictions of the user (such as the system reliance)at a minimum cost.

The IMPACTS module was used to estimate the GHG of the energy scenario. This module also determines by using a computer the water and soil pollution as well as air polluted agents such as: NO_x, SO_x., SO_x, CO, lead and particulate matter. We can carry out forestation, agricultural and environmental studies by using this model.

In the present study we projected the future GHG emissions by transferring the results of the BALANCE module to the IMPACT one and adjusting at the same time the GHG emission factors to the ones recommended by the International Panel of Climate Change. The ENPEP modules used in this study were: PLANDATA, MAED, LDC AND KARUS.

PLANDATA, is a technical data library about electric generation technology.

MAED is a model aimed at the analysis of energy demand. It determines the energy demand as part of the total energy demand.

LDC uses the charge duration curves to represent the electricity charge with respect to the time.

ICARUS is a model aimed at the cost research and electricity systems reliance. It determines in detail the electricity generation costs in respect to the delivering.

I.1.5.1.1 Energy Network

As decided at the cooperative Agreement between Peru and the Country Study Program of USA, 1990 was the base year for the Peruvian Energy Network. The energy network is a structure that represents the energy network of a country, it includes mainly the national and foreign energy resources, the conversion process of resources in refineries (such as power plants, coke and gas plants), transportation, transmission , distribution and conversion of primary and secondary resources into useful energy as well as demand sectors.

Figure I.1.3 shows in a simple form the Peruvian energy network. Appendix A shows the whole energy network used for the base scenario and mitigation options.

The use of an energy network makes easy to design the energy system (which includes the energy supply and demand) and analyze economic agents such as: economic growth, demographic agents and other energy parameters which affect the country development.

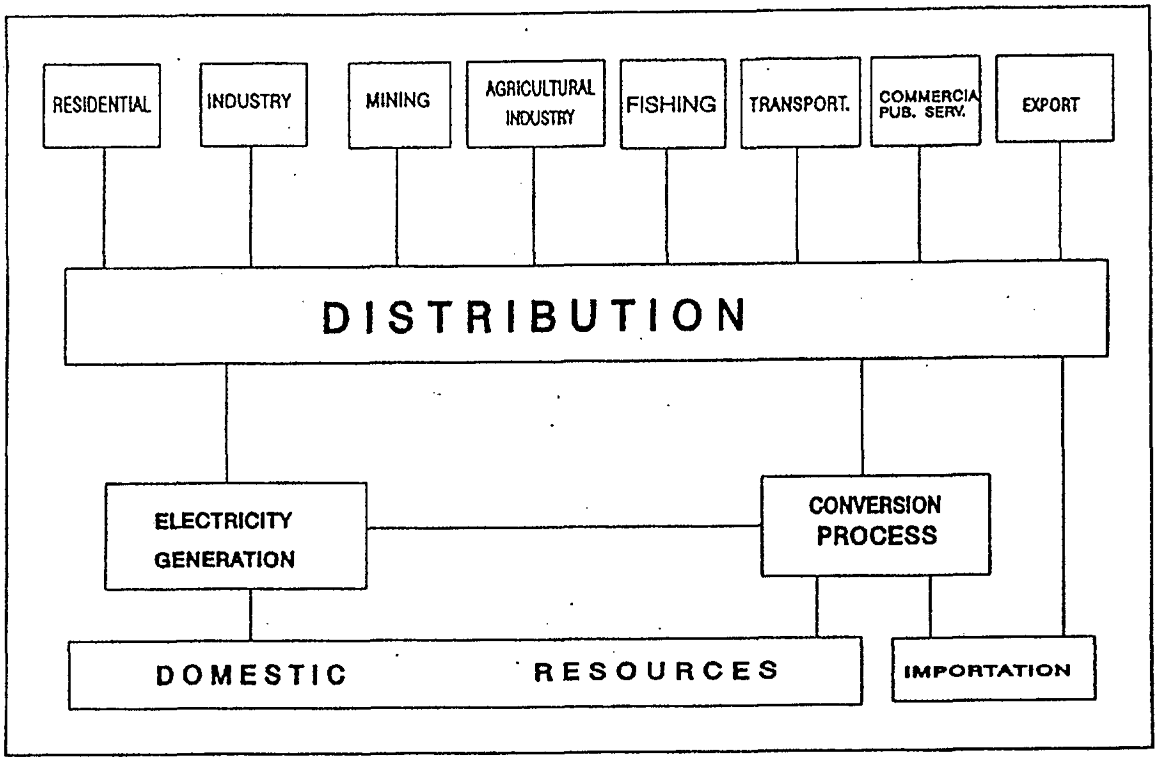

Fig. I.1.3 Simplified peruvian energy network.

I.1.5.2 Energy Demand/Base Year

According to the cooperative Agreement between USA- PERU, 1990 was established as the base year for this project. The projected energy demand was based on the energy demand structure made by the National Energy Council (CONERG) of the Ministry of Energy and Mines. It was considered the following sectors: RESIDENTIAL, INDUSTRIAL, MINING, FISHING, TRANSPORTATION, COMMERCIAL, SERVICES, PUBLIC, AGRICULTURE CATTLE and AGRICULTURAL INDUSTRY and EXPORTATION.

Table I.1.10 shows the final energy consumption sectors and the different fuels used by them. The sectors were established to carry out mitigation studies. It also shows the total energy resources exportation in oil equivalent barrels (BOE). The table is a summary of the energy consumption for the demanding sectors established in the energy balance (table I.1.2)

ENERGY CONSUMPTION IN 1990
UNITS : KBOE

RESOURCES	Residential		Transportation		Industry	Mining	Fishing		Commer Pub. Serv.	Agricult. Industry	TOTAL
	Urban	Rural	Pasang.	Freigh			Extract.	Transf.			
Gasoline	0.00	0.00	5615.86	2767.46	24.46	82.86	2.19	0.00	538.74	18.98	9050.54
Kerosene	3285.60	1647.29	386.88	1227.58	10.22	33.58	0.00	0.00	498.19	1.46	7090.78
LPG	1295.80	23.40	0.00	0.00	0.00	15.33	0.00	0.00	43.71	0.00	1378.24
Diesel	0.00	0.00	2311.58	5245.38	674.52	368.65	275.68	15.59	917.61	135.78	9944.79
Residual	0.00	0.00	79.20	653.72	4082.18	1984.07	0.00	1210.49	165.20	495.74	8670.58
Coal	54.24	0.00	0.00	0.00	354.05	57.31	0.00	0.00	0.00	0.00	465.60
Wood	818.20	18335.08	0.00	0.00	3245.67	0.00	0.00	0.00	5.82	0.00	23404.75
Dung	0.00	1894.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1894.28
Bagasse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	896.73	896.73
Coke	0.00	0.00	0.00	0.00	0.00	195.93	0.00	0.00	0.00	0.00	195.93
Charcoal	107.16	135.64	0.00	0.00	0.00	0.00	0.00	0.00	661.67	0.00	904.47
Distrib. Gas	335.07	0.00	0.00	0.00	207.32	0.00	0.00	0.00	0.00	0.00	542.39
Industrial Gas	0.00	0.00	0.00	0.00	68.62	0.00	0.00	0.00	0.00	0.00	68.62
Electricity	1569.50	40.90	0.00	0.00	2460.83	2041.81	0.00	73.00	1068.70	148.92	7403.66
Non Energy	0.00	0.00	41.00	41.00	15.33	33.73	0.00	0.00	11.32	0.00	1526.00
Exportation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16528.10
Total Consumption	7465.57	23076.57	8434.52	9935.14	11143.18	4813.26	277.87	1299.08	3910.96	1697.61	89965.46

Table I.1.10 Energy Consumption for the base year 1990.

I.1.5.2.1 USEFUL ENERGY DEMAND/ BASE YEAR

Useful energy- referred to as energy under the form of heat, light, power etc- is used by the different energy demand sectors. Tables I.1.11 to I.1.18 present the energy demand according to fuel type, use, effectiveness and distribution [13].

Table I.1.11 shows fuel transformation effectiveness into useful energy through different equipments used by the Rural Residential sector in order to obtain useful energy and meet ligthing, cooking and heating necessities. It also presents the energy fractions distributed for each demand type and the energy used by the Urban Population in each activity. Tables I.1.12 to I.1.18 show a structure similar to the one in table I.1.11. It contains efficiency, fractions and energy consumption for the Rural Residential subsector as well as for the following sectors: Commercial, Public services, Mining, Industrial, Agriculture Cattle and Agricultural Industry, Transportation and Fishing.

DOMESTIC URBAN SECTOR

Useful Energy Demand	EE			LPG			KE			DG			WO			CO			CH		
	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy
Lighting	6.4	21.1	331.2				1.6	1.9	62.43												
Cooking	80	7	109.9	45	99.9	1295	35.5	97.9	3217	45	100	335.1	10	100	818.19	28	100	64.2	25	100	107.1
Water Heat	94.4	18.7	293.5	45.1	0.1	1.3	35.6	0.2	6.67												
Refrigeration and Ventilation Electric Appliances	94	35.7	560.3																		
Food Preservation and Heating	80	17.5	274.7																		
Total Consumption (1000 BOEs)		100	1570		100	1296		100	3286		100	335		100	818.2		100	54.2		100	107

Table I.1.11 Efficiencies of Final Energy Transformation to Useful Energy in different ways of energy consumption in DOMESTIC URBAN sector.
EFFICIENCIES (%), SPLITS (%) and ENERGY CONSUMPTION (BOEs)

DOMESTIC RURAL SECTOR

Useful Energy Demand	EE			LPG			KE			DU			WO			CO			CH		
	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy
Lighting	6.4	34.4	14.06				1.5	29.9	492.5												
Cooking and Water Heat	35	0.1	0.04	45	100	23.36	35	69.2	1140	10	100	1894	9.2	100	19335	28	100	0	16	100	135.6
Food Preservation	80	28.6	11.7				6	0.9	14.82												
Refrigeration and Ventilation Electric Appliances	87	36.9	15.08																		
Total Consumption (1000 BOEs)		100	40.9		100	23.4		100	1647		100	1894		100	19335		100	0		100	136

Table I.1.12 Efficiencies of Final Energy Transformation to Useful Energy in different ways of energy consumption in DOMESTIC URBAN sector.
EFFICIENCIES (%), SPLITS (%) and ENERGY CONSUMPTION (BOEs)

COMMERCIAL, SERVICE AND PUBLIC SECTOR

Useful Energy Demand	CH			DO			EE			LPG			GM			KE and TC			WO			RE		
	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy
Lighting							8.8	49	523.7							16.7	0.9	4.49						
Heat	20	100	661.6	61.3	9.1	86.2	86.4	2.2	23.51	45.3	100	43.73				25.1	7.7	38.36	20	100	5.84	70.8	100	165.2
Motive Power				32	90.9	861.1	78.3	37.5	400.8				18	100	538.7	18	91.4	455.38						
Refrigeration and Preservation Electro-chemistry Appliances							87	11.3	120.8															
Total Consumption (1000 BOEs)		100	662		100	947		100	1069		100	43.7		100	539		100	498.2		100	5.84		100	165

Table I.1.13 Efficiencies of Final Energy Transformation to Useful Energy in different ways of energy consumption in COMMERCIAL, SERVICES and PUBLIC sector.
EFFICIENCIES (%), SPLITS (%) and ENERGY CONSUMPTION (BOEs)

MINNIG SECTOR

Useful Energy Demand	CK			DO			EE			LPG			GM			KE			CO			RE		
	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy
Lighting							15	5.2	106.2															
Heat Processes				85	2.9	10.69	85	0.7	14.29													85	3.9	77.38
Direct Heat	66	100	195.9	35	12.2	44.98				28	100	15.3							66	100	57.3	28	94.9	1883
Water Pumping							70	0.9	18.37															
Ventilation Motive Power				32	54.9	202.4	90	68.4	1396				18	1.2	0.99									
Electrolysis							95	24.2	494															
Heavy Transport				24	30	110.6	85	0.6	12.25				18	98.8	81.91	21	100	33.6				16	1.2	23.81
Total Consumption (1000 BOEs)		100	196		100	369		100	2042		100	15.3		100	82.9		100	33.6		100	57.3		100	1984

Table I.1.14 Efficiencies of Final Energy Transformation to Useful Energy in different ways of energy consumption in MINNING sector.
EFFICIENCIES (%), SPLITS (%) and ENERGY CONSUMPTION (BOEs)

INDUSTRY SECTOR

Useful Energy Demand	CO			WO			IG			DG			KE			GM			DO			RE			EE		
	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy
Lighting																									19	2.4	59.06
Heat Process													70.9	0.2	0.02				70.8	8.7	45.19	70.8	41.8	1698	70.8	2.1	51.89
Direct Heat	28	100	354.1	20	100	3246	28	100	68.6	45	100	207.3	29.2	98.9	10.09				35	78.0	538.9	30	58.4	2584	34.1	52.2	1285
Electro-chemes. Proc. Food Preservation																									80	8.4	206.7
Motive Power Heavy Transport													18	0.9	0.08	18	100	24.5	24	13.4	90.38				84.8	34.9	858.8
Total Consumption (1000 BOEs)		100	354.1		100	3246		100	68.6		100	207.3		100	10.2		100	24.5		100	674.5		100	4282		100	2461

Table I.1.15 Efficiencies of Final Energy Transformation to Useful Energy in different ways of energy consumption in INDUSTRIAL sector.
EFFICIENCIES (%), SPLITS (%) and ENERGY CONSUMPTION (BOEs)

AGRICULTURE CATTLE AND AGRICULTURAL INDUSTRY SECTOR

Useful Energy Demand	BG			DO			EE			GM			RE		
	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy
Lighting							15.6	10.3	15.31						
Heat	63.6	87.5	784.6	67.5	34	46.17	83.1	4.6	6.84				69.8	96	476
Motive Power	27.2	12.5	112.1	25.2	65.4	88.82	88.8	84.2	125.1	18	68.6	13.03	29.3	4	19.83
Refrigeration and Preservation							79.4	0.8	1.19						
Electrochemetry Processes and Other				23.3	0.6	0.8	83.3	0.1	0.15	15.2	31.4	5.97			
Total Consumption (1000 BOEs)		100	896.7		100	135.8		100	148.6		100	19		100	495.8

Table I.1.16 Efficiencies of Final Energy Transformation to Useful Energy in different ways of energy consumption in AGRICULTURE CATTLE and AGRICULTURAL INDUSTRY sector.
EFFICIENCIES (%), SPLITS (%) and ENERGY CONSUMPTION (BOEs)

FREIGHT TRANSPORT

Useful Energ Demand	GM			DO			RE			KE and TC		
	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy
Highway	18	100	2767	24	85.1	4464						
Railroad				28.1	4.3	225.6	6.7	1.1	7.19			
Air										25	98.8	1219
Ocean and River				20	10.6	556	7	98.9	646.5	13	1.2	14.8
Total Consumption (1000 BOEs)		100	2767		100	5245		100	654		100	1233

PASSENGER TRANSPORT

GM			DO			RE			KE and TC		
Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy	Eff.	Split	Energy
18	100	5616	24	94.6	2187						
			28.3	5.4	124.8	6.7	100	79.23			
									25	100	388.7
	100	5616		100	2312		100	79.2		100	389

Table I.1.17 Efficiencies of Final Energy Transformation to Useful Energy in different ways of energy consumption in TRANSPORTATION sector.
EFFICIENCIES (%), SPLITS (%) and ENERGY CONSUMPTION (BOEs)

FISHING TRANSFORMATION SECTOR

Useful Energy Demand	DO			RE			EE		
	Eff	Split	Energy	Elec.	Split	Energy	Elec.	Split	Energy
Lighting							18.1	2.1	1.53
Heat Processes				52	100	1211			
Food preservation							80	0.3	0.22
Motive Power	45	100	15.6				85	97.6	71.3
Total Consumption (1000 BOEs)		100	16		100	1211		100	73

FISHING EXTRACTION SECTOR

Useful Energy Demand	GM			KE			DO		
	Eff.	Split	Energy	Elec.	Split	Energy	Elec.	Split	Energy
Lighting									
Cooking				25	100	0.1			
Food preservation									
Motive Power	17.8	100	2.2				45	100	275.7
Total Consumption (1000 BOEs)		100	2.2	25	100	0.1	45	100	276

Table I.1.18 Efficiencies of Final Energy Transformation to Useful Energy in different ways of energy consumption in FISHING sector.
EFFICIENCIES (%), SPLITS (%) and ENERGY CONSUMPTION (BOEs)

I.1.5.3 ENERGY OFFER AND DEMAND PROJECTED FOR 1990-2015

The energy offer and demand balances have been projected for the period 1990-2015 by using the ENPEP model and according to the macroeconomic base scenario as well as data about the base year 1990.

The adequate fuels for each use have been chosen in the present model, considering the demand, the availability and fuel costs during the whole energy cycle process, that is to say, from their extraction or importation to their exportation or final consumption as useful energy. The fuels with major consumption for the period of study are those which come from crude oil. Since Peru does not have great sizeable oil reserves and one of our challenges is to preserve the environment, it is necessary to restrict the use of energy resources, design suitable policies aimed at a clear energy use and create effective consumption systems and equipments.

Wood contributes in great extent to the country energy system. For this reason, it is also necessary to design a policy for the use of a cleaner fuel instead of wood or more efficient furnaces and cooks.

Figure I.1.4 shows the energy consumption of the Urban Subsector. This subsector uses kerosene in great quantities and is a great emitter of CO_2. For this reason, it is necessary to focus the mitigation options in this subsector.

Figure I.1.5 presents the energy consumption of the Rural Subsector. This subsector mainly uses wood which is an energy resource with low effeciency and emits great quantities of CO_2. Due to this fact, it is necessary to design governmental policies aimed at the use of resources with lower CO_2 emissions instead of wood.

Since the use of LPG is very small in this sector, it constitutes an option for replace wood with GLP which use is more easy and less polluting. Nevertheless, as it is impossible to eliminate definitively the use wood, the technologies must to be improved.

Figure I.1.6 shows the energy consumption of the industrial sector. This sector uses great quantities of wood, residual oil and diesel. Since wood is used for bread industry, the replacement of this resource with another one implies also a technology change. For this reason, the mitigation options of this sector are related to new or improved technologies applied to different activities. The Industrial sector uses also gasoline and kerosene but they are worthless in relation to others fuels, that is why they do not appear in figure I.1.6

Figure I.1.7 shows the energy consumption for the Transportation sector. This is an important sector because it represents great part of the total energy consumption,mainly of the fuels which come from crude oil. It is an important sector for the CO_2 mitigation studies.
Figure I.1.8 shows the energy consumption for the Fishing sector. Figure I.1.9 represents the energy consumption of the Mining Sector, it does not include kerosene consumption because of its low quantity.

Table I.1.11 shows the energy consumption of the Agriculture Catlle And Agricultural Industry sectors. Picture I.1.12 shows the total fuel consumption of all sectors. It can be noted that wood, residual, diesel, gasoline and kerosene are the most important fuels.

Figure I.1.13 represents the total consumption for each sector. The sectors with major energy cosumption are: Residential, Industrial and Transportation. The Industrial sector has the major growth. The mitigation options of the project "Peru Climate Change Country Study" will be mainly focused in these sectors.

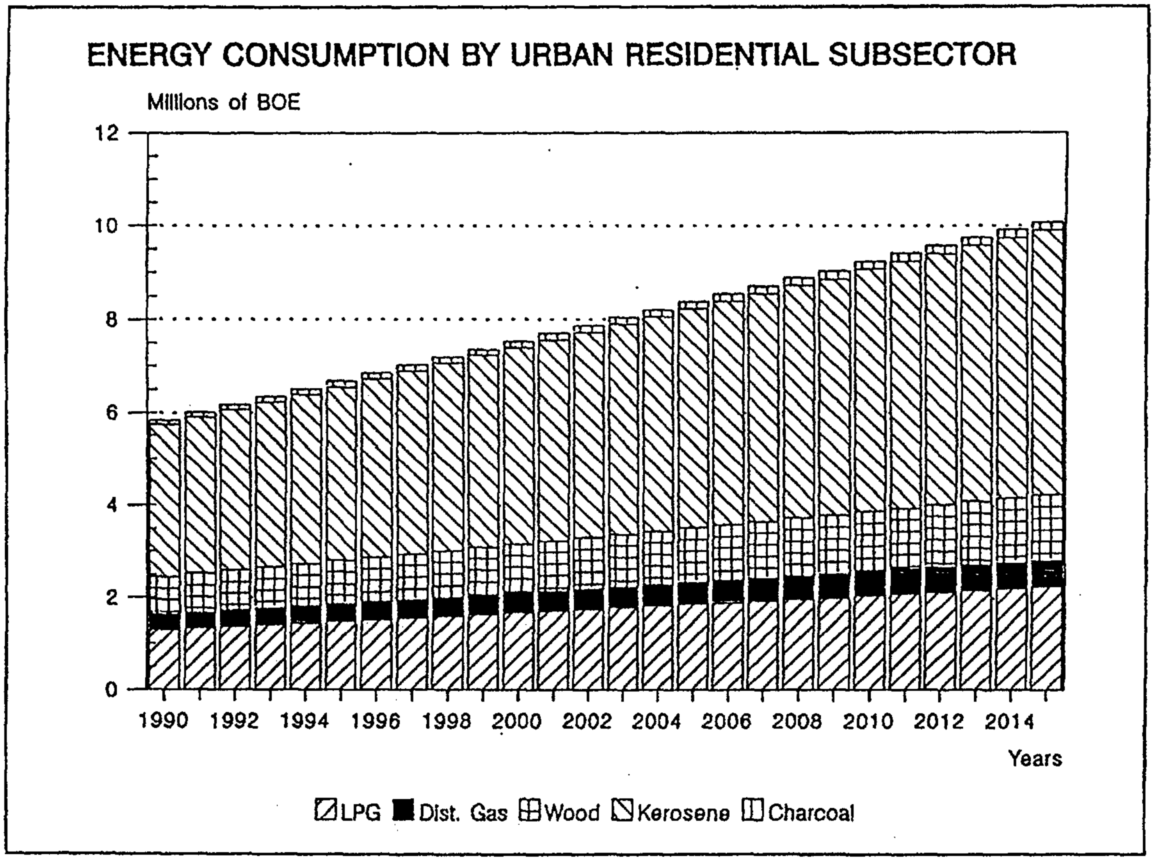

Fig. I.1.4 Energy consumtion projected for the urban residencial subsector.

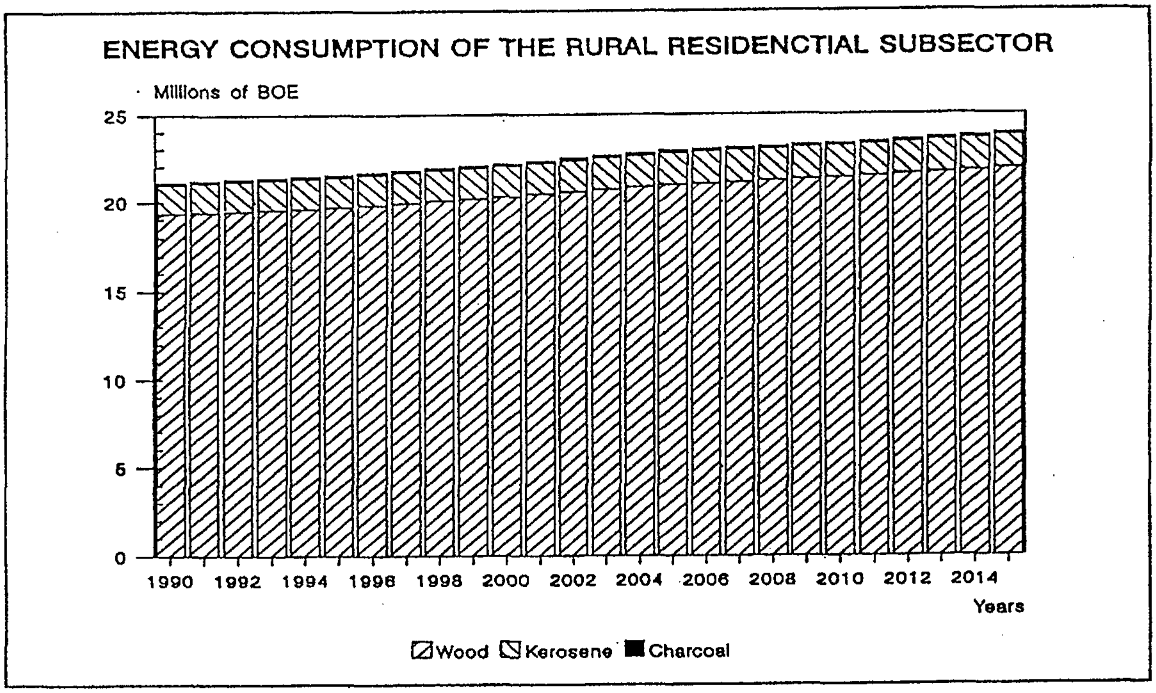

Fig. I.1.5 Energy consumption projected for the rural residential subsector.

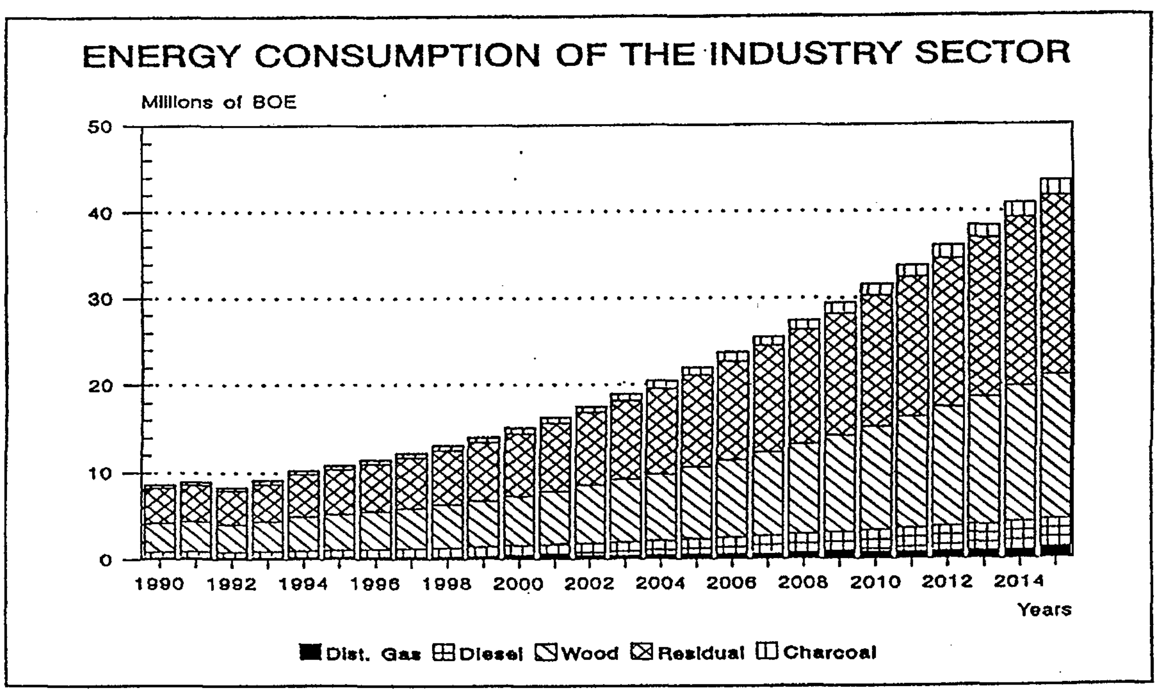

Fig. I.1.6 Energy consumption projected for the industrial sector.

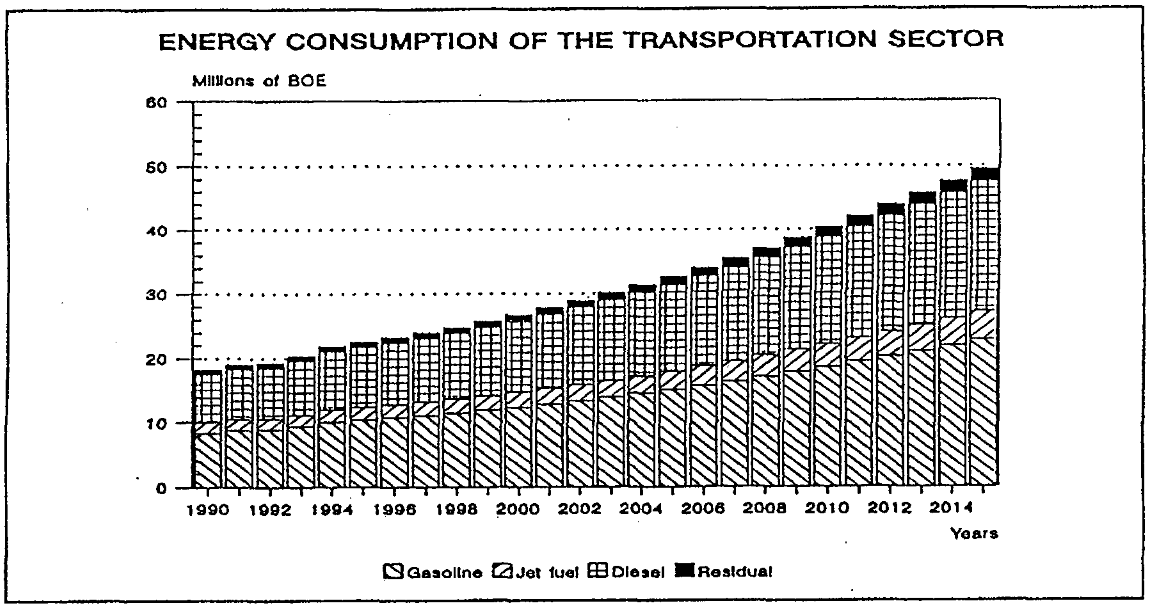

Fig. I.1.7 Energy consumption projected for the transportation sector.

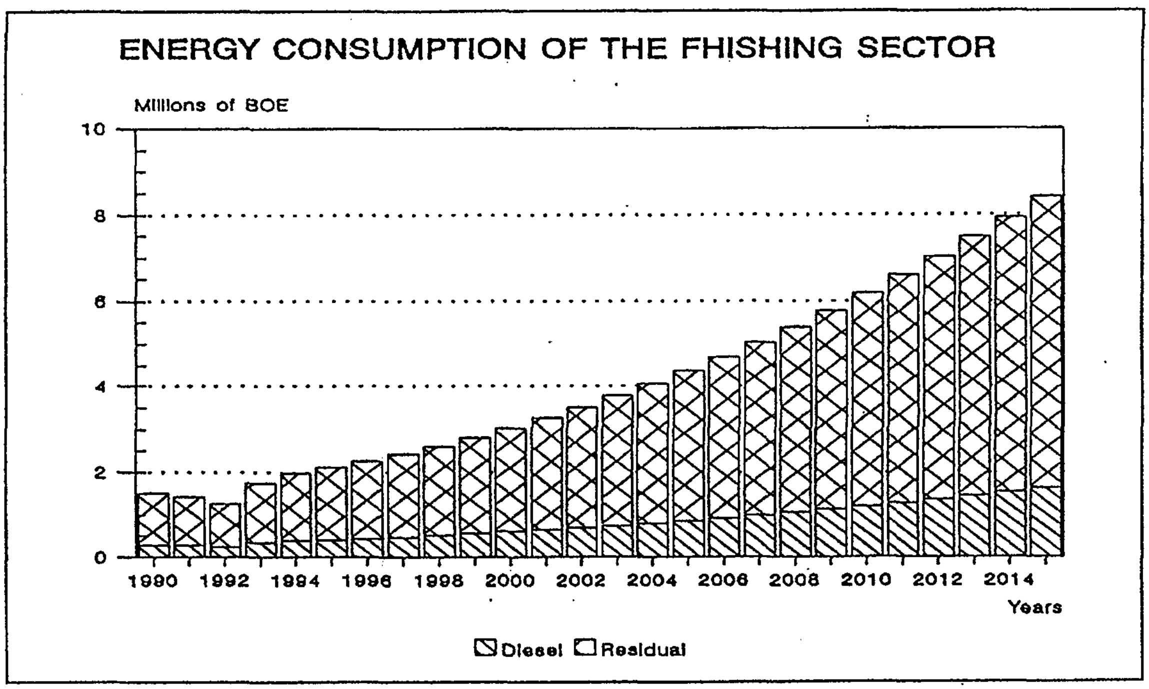

Fig. I.1.8 Energy consumption projected for the fishing sector.

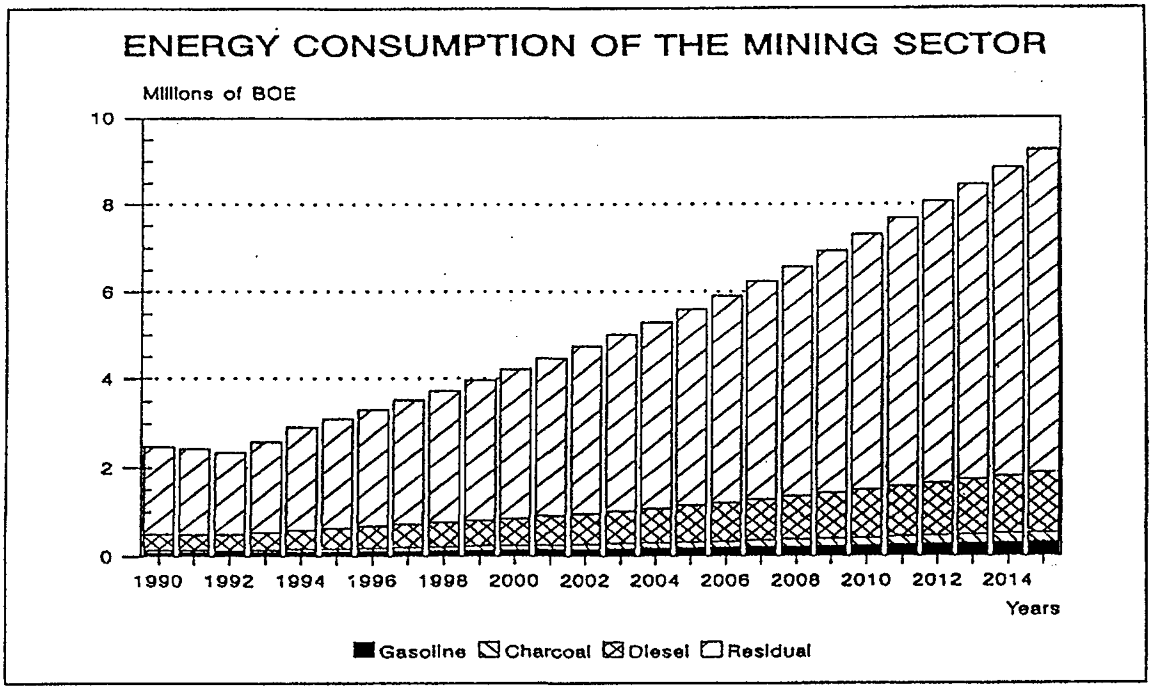

Fig. I.1.9 Energy consumption projected for the mining sector.

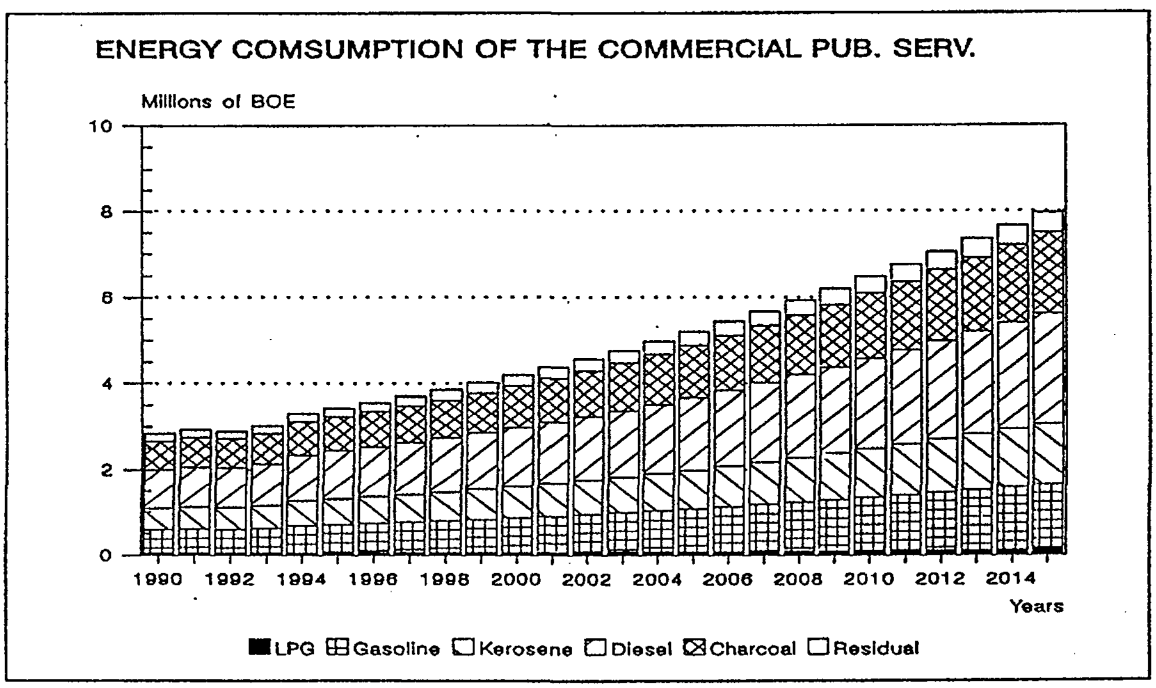

Fig. I.1.10 Energy consumption projected for the commercial and public services sector.

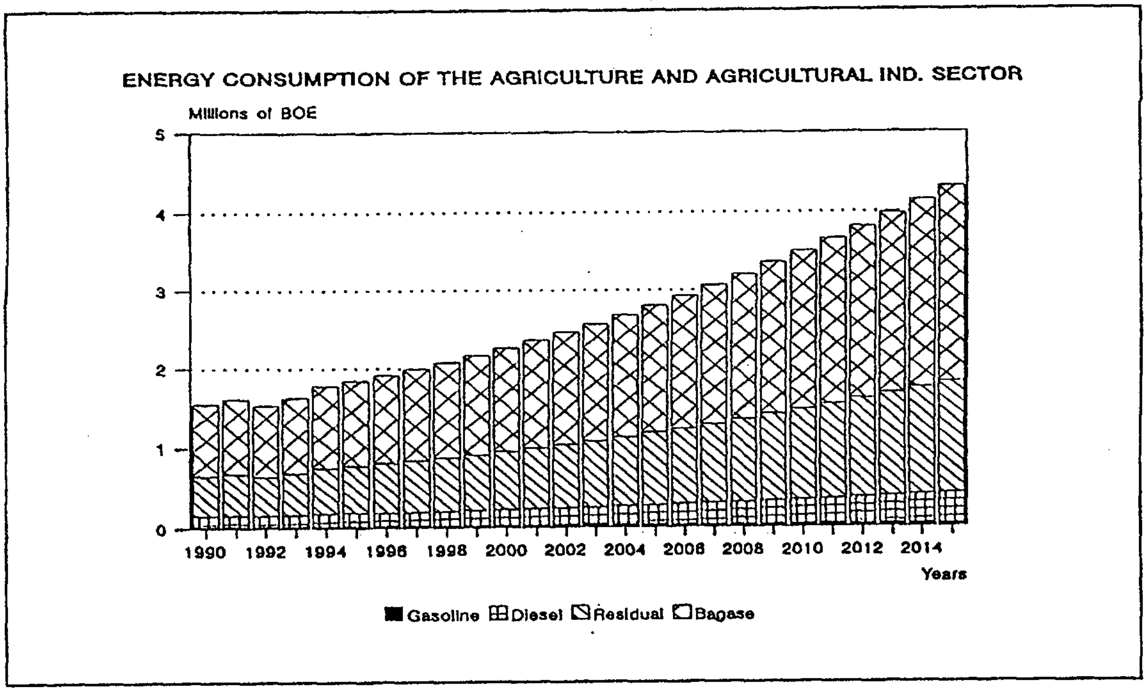

Fig. I.1.11 Energy consumption projected for the Agricultural Industry sector.

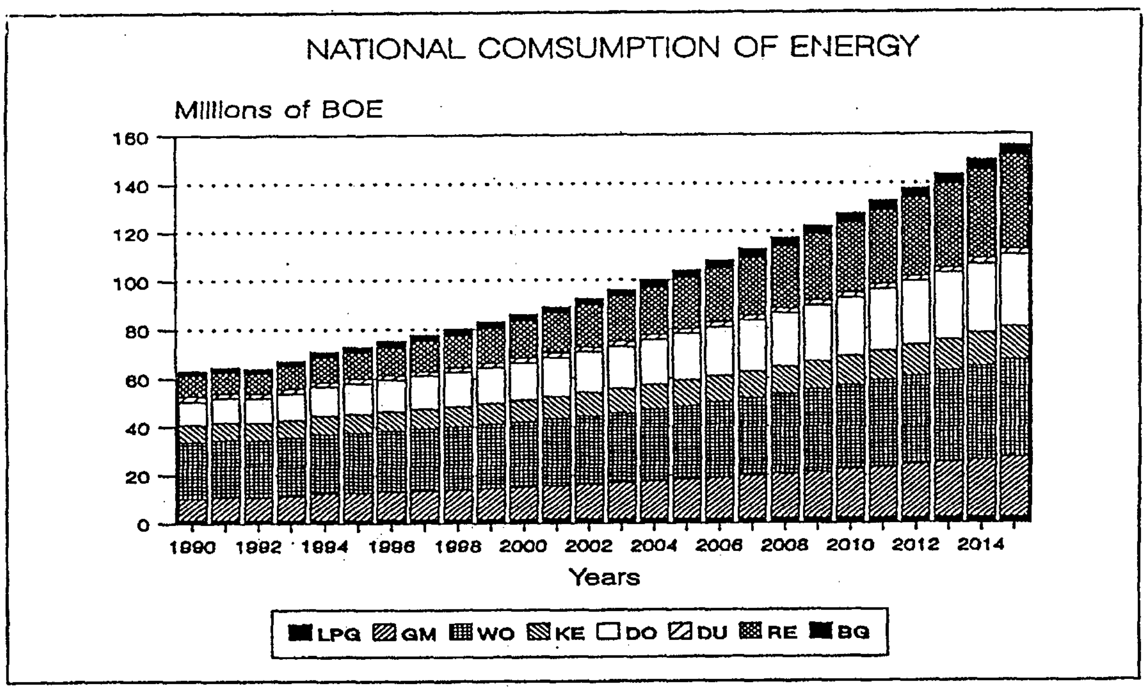

Fig. I.1.12 Total energy requirement for all demanding sectors for the period in beetwen 1990 and 2015.

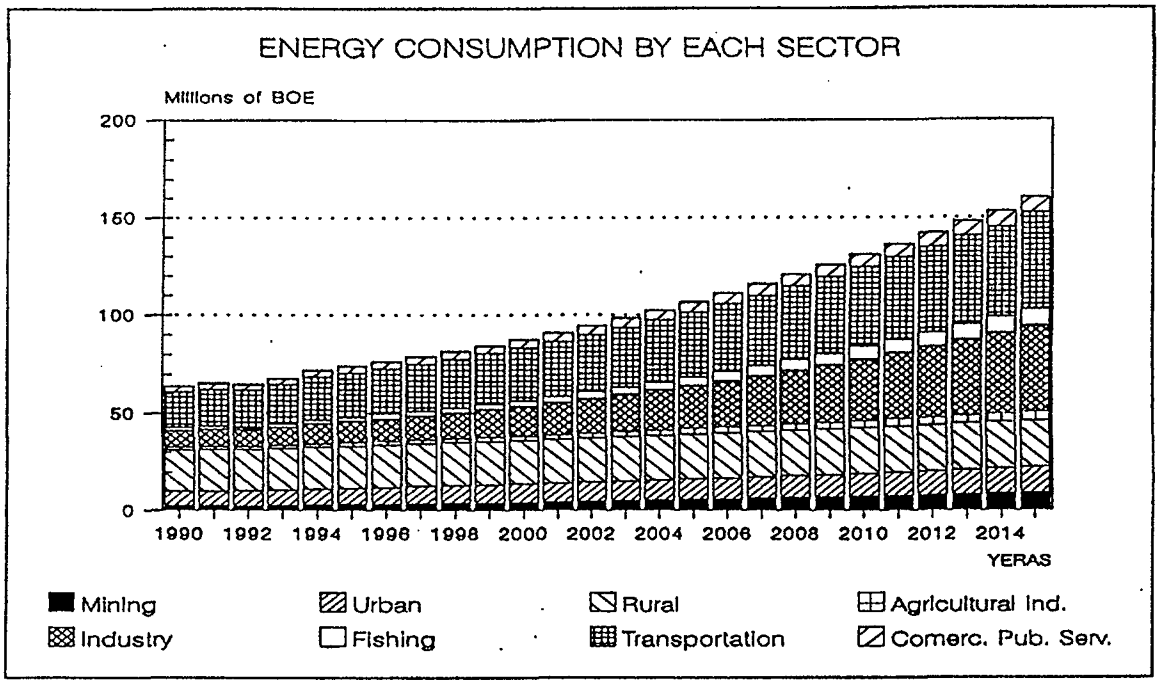

Fig. I.1.13 Energy consumption projected by sectors for the period in beetwen 1990 and 2015.

I.1.6 GHG EMISSIONS FOR THE BASE SCENARIO

The IMPACT module of the ENPEP was used to estimate GHG emissions. The data of this module was previously transferred to the BALANCE and ELECTRIC module which were also analyzed. The energy system projections were obtained by using the BALANCE module. The electricity generation projections were acquired by using the ELECTRIC model, optimizing in this way the country electric system expansion.

The CO_2 emission that results from the energy consumption for the whole energy system have been quantified. These include the energy consumption used in the extraction of primary resources (such as oil, gas and coal) production of fuels and electricity (in refineries, gas plant and power plants) and energy consumption in the following sectors: Urban and Rural Residential, Transportation, Industrial, Commercial, Mining, Public Services, Fishing and Agricultural Industry. Table I.1.19 shows the CO_2 emission for the demanding sectors, the conversion activities of primary energy resources into secondary fuels (referred to as process and own consumption) and the electricity generation for the base mitigation scenario of the Peruvian energy sector.

According to the results of GHG inventory [7], this study only focuses the CO_2 mitigation as the most important for the case of Peru.

Making a comparison between the obtained CO_2 emission based on the IPCC methodology (35.34 MMT) and the ENPEP model (35.76 MMT), a difference of 1.2% is obtained. This aspect makes evident that the results and methodologies are consistent.

CO2 EMISSION FOR THE MITIGATION BASE SCENARIO
In millions of tonnes

Years	Rural Residential	Urban Residential	Commerc. & Public	Transport	Agricult. Industry	Mining	Fishing	Industry	Process & Own Cons.	Electricity Generation	TOTAL
1990	12.39	2.68	1.25	7.46	0.77	1.21	0.66	4.14	2.50	2.69	35.76
1991	12.44	2.76	1.29	7.77	0.80	1.19	0.62	4.33	2.89	3.04	37.13
1992	12.49	2.84	1.27	7.86	0.77	1.15	0.55	4.00	2.87	2.96	36.76
1993	12.53	2.91	1.33	8.30	0.81	1.26	0.76	4.37	3.03	3.12	38.41
1994	12.58	2.99	1.46	8.93	0.89	1.41	0.86	4.94	3.27	3.35	40.68
1995	12.63	3.07	1.52	9.22	0.92	1.51	0.92	5.22	3.40	3.48	41.88
1996	12.70	3.15	1.58	9.51	0.96	1.61	0.87	5.54	3.53	3.48	42.94
1997	12.77	3.23	1.64	9.82	1.00	1.71	1.06	5.91	3.65	4.00	44.78
1998	12.85	3.30	1.70	10.14	1.03	1.81	1.14	6.31	3.78	5.04	47.11
1999	12.92	3.38	1.78	10.53	1.08	1.93	1.23	6.79	3.93	5.60	49.16
2000	13.00	3.46	1.85	10.94	1.13	2.05	1.32	7.31	4.09	6.49	51.62
2001	13.08	3.54	1.94	11.37	1.18	2.17	1.42	7.87	4.26	6.48	53.31
2002	13.17	3.62	2.02	11.82	1.23	2.30	1.53	8.49	4.44	7.11	55.72
2003	13.25	3.70	2.11	12.30	1.28	2.43	1.65	9.15	4.63	7.74	58.24
2004	13.33	3.77	2.20	12.81	1.34	2.57	1.78	9.86	4.83	8.56	61.05
2005	13.42	3.85	2.30	13.34	1.40	2.72	1.91	10.62	5.05	9.18	63.79
2006	13.47	3.93	2.40	13.91	1.47	2.87	2.05	11.44	5.27	9.93	66.74
2007	13.52	4.01	2.51	14.51	1.53	3.03	2.20	12.31	5.52	10.76	69.89
2008	13.57	4.09	2.63	15.15	1.60	3.20	2.36	13.24	5.77	11.69	73.29
2009	13.62	4.15	2.75	15.81	1.68	3.37	2.53	14.21	6.03	12.60	76.74
2010	13.67	4.24	2.87	16.49	1.75	3.55	2.70	15.23	6.32	13.55	80.37
2011	13.73	4.32	2.99	17.19	1.83	3.73	2.88	16.30	6.60	14.61	84.19
2012	13.80	4.40	3.12	17.92	1.91	3.92	3.07	17.42	6.90	15.65	88.10
2013	13.87	4.48	3.25	18.66	1.99	4.11	3.26	18.58	7.21	16.80	92.22
2014	13.93	4.56	3.39	19.43	2.08	4.31	3.46	19.79	7.53	17.94	96.40
2015	14.00	4.63	3.53	20.22	2.16	4.51	3.67	21.04	7.86	19.18	100.80

Tabla I.1.19 CO_2 emissions for the base scenario in the demand sector: Proces and own consumption, electricity generation.

Figure I.1.14 shows the CO_2 emission by sectors for the mitigation base scenario.

According to the results shown in table I.1.19, the most important sectors for mitigation options are: Transportation, Industrial, Residential as well as Electricity generation. In the Transportation sector, the emissions increase from 7.46 to 20.22 MMT, in the Industrial Sector it increase from 4.14 to 21.04 MMT, in the Urban Residential sector it increase from 12.39 to 14.00 MMT and in the Electricity generation it increase from 2.69 to 19.18 MMT.

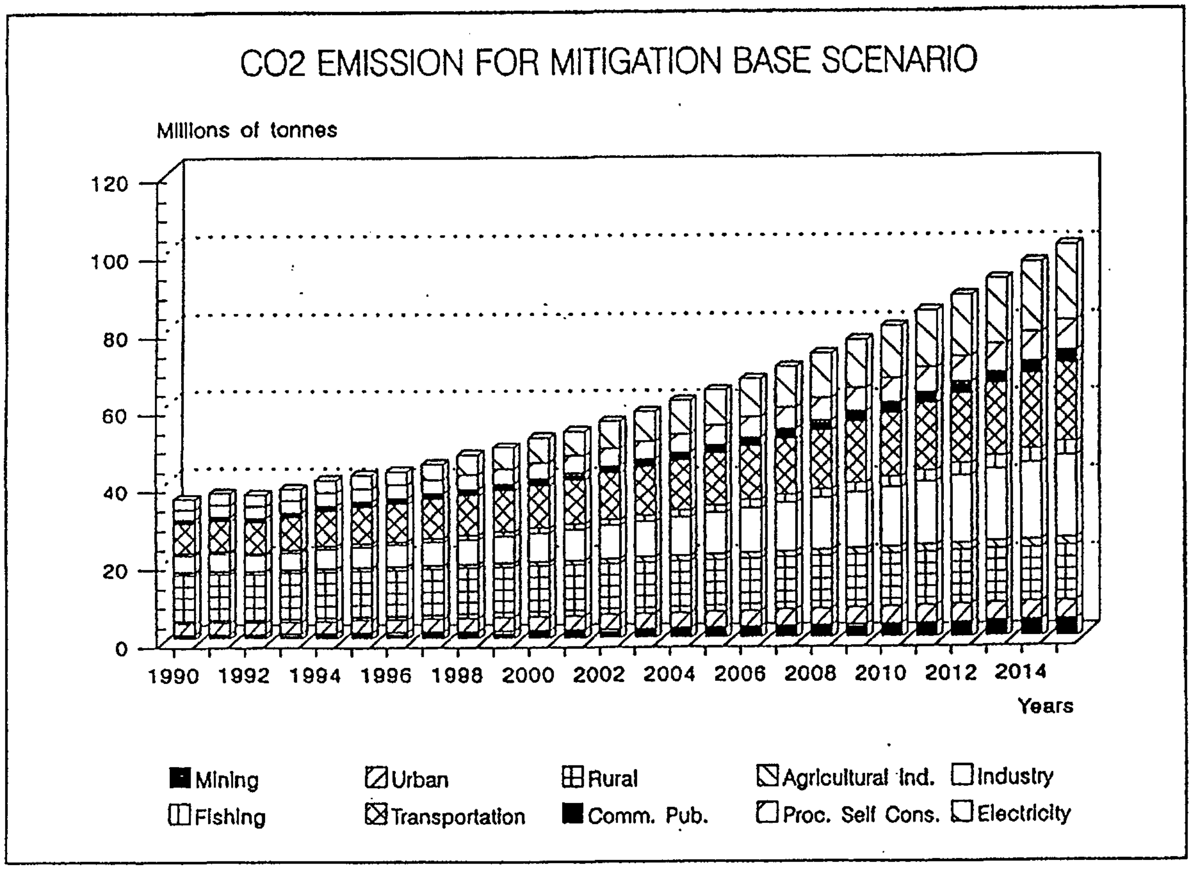

Fig. I.1.14 Total emission of CO_2 by each sector for the base scenario in between 1990 and 2015.

I.2 MITIGATION SCENARIO

I.2.1 MITIGATION SECTORS

According to the GHG emission Inventory for 1990, [7, 11, 16, 17, 18], the most important sectors of energy consumption and CO_2 emission are: the Residential sector (composed by the Urban and Rural Residential), Transportation, Industrial and Conversion Activity. For this reason, we have elaborated mitigation proposals for each sector and for electricity generation.

Table I.2.1 shows the base scenario emissions and the mitigation options for Rural and Urban Residential Sectors, Transportation, Industrial and Electricity generation by thermal plants.

CO_2 EMISION BY SECTORS WITH MITIGATION 1990 - 2015
UNITS : Millions of Tonnes

Years	Rural Residential		Urban Residential		Transportation		Industrial		Electricity Generation	
	without Mitigation	with Mitigation	without Mitigation	with Mitigation	Without Mitigation	with Mitigation	without Mitigation	with Mitigation	without Mitigation	with Mitigation
1990	12.39	12.39	2.68	2.68	7.46	7.46	4.14	4.14	2.69	2.69
1991	12.44	12.44	2.76	2.76	7.77	7.77	4.33	4.33	3.04	3.04
1992	12.49	12.49	2.84	2.84	7.86	7.86	4.00	4.00	2.96	2.96
1993	12.53	12.53	2.91	2.91	8.30	8.30	4.37	4.37	3.12	3.12
1994	12.58	12.58	2.99	2.99	8.93	8.93	4.94	4.94	3.35	3.35
1995	12.63	12.63	3.07	3.07	9.22	9.22	5.22	5.22	3.48	3.48
1996	12.70	12.70	3.15	3.15	9.51	9.24	5.54	5.54	3.48	3.48
1997	12.77	12.78	3.23	3.23	9.82	9.20	5.91	5.91	4.00	4.00
1998	12.85	12.85	3.30	3.30	10.14	9.27	6.31	6.31	5.04	5.04
1999	12.92	12.68	3.38	3.38	10.53	9.41	6.79	6.79	5.60	5.58
2000	13.00	12.51	3.46	3.46	10.94	9.56	7.31	7.31	6.49	5.81
2001	13.08	12.35	3.54	3.52	11.37	9.73	7.87	7.58	6.48	5.83
2002	13.17	12.18	3.62	3.58	11.82	9.92	8.49	7.85	7.11	6.16
2003	13.25	12.02	3.70	3.64	12.30	10.13	9.15	8.16	7.74	6.65
2004	13.33	11.85	3.77	3.71	12.81	10.37	9.86	8.51	8.56	7.38
2005	13.42	11.69	3.85	3.77	13.34	10.63	10.62	8.89	9.18	7.83
2006	13.47	11.51	3.93	3.83	13.91	11.02	11.44	9.31	9.93	8.19
2007	13.52	11.34	4.01	3.89	14.51	11.43	12.31	9.75	10.76	8.93
2008	13.57	11.17	4.09	3.95	15.15	11.87	13.24	10.24	11.69	9.74
2009	13.62	11.18	4.15	4.00	15.81	12.34	14.21	10.75	12.60	10.40
2010	13.67	11.19	4.24	4.07	16.49	12.83	15.23	11.29	13.55	11.11
2011	13.73	11.21	4.32	4.13	17.19	13.33	16.30	11.87	14.61	11.88
2012	13.80	11.27	4.40	4.19	17.92	13.86	17.42	12.47	15.65	12.69
2013	13.87	11.26	4.48	4.25	18.66	14.40	18.58	13.10	16.80	13.64
2014	13.93	11.26	4.55	4.31	19.43	14.97	19.79	13.77	17.94	14.71
2015	14.00	11.28	4.63	4.47	20.22	15.55	21.04	14.46	19.18	15.85
TOTAL	343	311.43	95.05	93.08	331.41	278.57	264.41	217	225.03	193.54

Table I.2.1 Emission with and without mitigation for the Urban and Rural subsectors, Industrial and Transport sectors and electricity generation.

I.2.1.1 Residential sector

To accomplish mitigation studies in the Residential Sector, it was divided in: Urban residential and Rural Residential. It was necessary to make this division since each subsector does not use the same fuels and have different growth rates. As it can be observed from section I.1.5.3, the Urban Population uses mainly kerosene, GLP and wood in low quantities. The Rural Population uses mainly wood and kerosene in low quantities, for these reasons the government must apply different policies aimed at the improvement of the life standard and environmental preservation.

I.2.1.1.1 Mitigation in the urban residential subsector

The energy consumption has been identified by social levels in order to apply mitigation alternatives in this subsector. We have established high, middle, low and lower residential levels. Tables I.2.1, I.2.2, I.2.3 and I.2.4 show the energy consumption and efficiency for the base year.

FINAL ENERGY DEMAND FOR THE GIGH CLASS URBAN POPULATION FOR 1990.

Useful Energy Demand	EE			GPG			KE			CH			DG		
	Eff %	%	Energy (KBOE)	Eff %	%	Energy (KBOE)	Eff %	%	Energy (KBOE)	Eff %	%	Energy (KBOE)	Eff %	%	Energy (KBOE)
Cooking	80	11,28	41,78	45	99,73	104,53	35,5	100,0	42,47	25	100,0	1,07	45	100,0	184,31
Ligthting	8,4	19,92	73,78												
water Heat	94,4	28,00	100,14	45,1	0,27	0,44									
Refrigeration and Ventilation Electric Appliances	94	20,72	98,95												
Food Preservation and Heating		13,42	48,00												
TOTAL		100,0	370,32		100,0	104,97		100,0	42,47		100,0	1,07		100,0	184,31

Table I.2.2 Energy consumption of the high class Urban poputation for 1990.

FINAL ENERGY DEMAND FOR THE MID CLASS URBAN POPULATION FOR 1990.

Useful Energy Demand	EE			LPG			KE			WO			CH			DG		
	Eff %	%	Energy (KBOE)	Eff %	%	Energy (KBOE)	Eff %	%	Energy (KBOE	Eff %	%	Energy (KBOE)	Eff %	%	Energy (KBOE)	Eff %	%	Energy (KBOE)
Cooking	80	8,7	60,01	45	99,94	525,78	35,5	100,0	435,28	10	100,0	40,91	25	100,0	10,7	45	100,0	117,29
Lighting	8,4	17,05	124,04															
water Heat	94,4	22,11	160,84	45,1	0,10	0,86												
Refrigeration and Ventilation Electric Appliances	94	38,13	277,40															
Food Preservation and Heating	80	15,84	115,28															
TOTAL		100,0	727,55		100,0	526,64		100,0	435,28		100,0	40,91		100,0	10,7		100,0	117,29

Table I.2.3 Energy consumption of the middle class urban population for 1990.

FINAL ENERGY DEMAND FOR THE LOW CLASS URBAN POPULATION FOR 1990.

Useful Energy Demand	EE			LPG			KE			WO			CH			CO			DO		
	Eff %	%	Energy (KBOE)	Eff %	%	Energy (KBOE)	Eff %	%	Energy (KBOE)	Eff %	%	Energy(KBOE)	Eff %	%	Energy (KBOE)	Eff %	%	Energy (KBOE)	Eff %	%	Energy (KBOE)
Cooking	80	3,7	10,21	45	100	321,42	36,6	100	770,79	10	100	245,46	26	100	31,03	28	100	24,39	46	100	33,51
Lighting	6,4	22,7	62,81																		
Heat Water	94,4	7,4	20,40																		
Refrigeration and Ventilation Electric Appliances	94	42,4	117,95																		
Food Preservation and Heating	80	23,8	66,12																		
TOTAL		100	277,49		100	321,42		100	770,79		100	245,46		100	31,03		100	24,39		100	33,51

Tabla I.2.4 Energy consumption of the low class Urban Population for 1990.

FINAL ENERGY DEMAND FOR THE LOWEST CLASS URBAN POPULATION FOR 1990.

Useful Energy Demand	EE			LPG			KE			WO			CH			CO		
	Eff %	%	Energy. (KBOE)	Eff %	%	Energy (KBOE)	Eff %	%	Energy (KBOE)	Eff %	%	Energy (KBOE)	Eff %	%	Energy (KBOE)	Eff %	%	Energy (KBOE)
Cooking	80	4,1	7,91	45	100	283,35	36,6	100	1968,48	10	100	531.82	26	100	64,2	28	100	29,81
Lighting	6,4	36,3	70,61															
Water Heat	94,4	3,2	6,16															
Refrigeration and Ventilation Electric Appliances	94	34.0	66,0															
Food Preservation and Heating	80	22,4	43,63															
TOTAL		100,0	194,3		100	283,35		100	1968,48		100,0	531.82		100	64,2		100	29,81

Table I.2.5 Energy consumption of the lowest class Urban Population for 1990.

The high social level uses mainly electricity. The middle class uses electricity, GLP and kerosene in similar quantities. In the lower and lowest levels, the kerosene and wood are the most important fuels, having kerosene the major consumption. The electricity consumption has not been considered,since the emission for this kind of energy is produced in the electricity generation and not in the electricity consumption.

Since the low social subsector uses kerosene in great quantities, it is proposed that from 2001 the new kerosene demand would be substituted by natural gas or LPG. We assume the availability of this resource by that time.

Figure I.2.1 shows the mitigation option for the urban Residential Subsector. It can be noted a reduction of 0.3 MMT of CO_2 compared with the base scenario in 2015 and a total reduction of 1.97 MMT in the whole period of study (1990-2015)

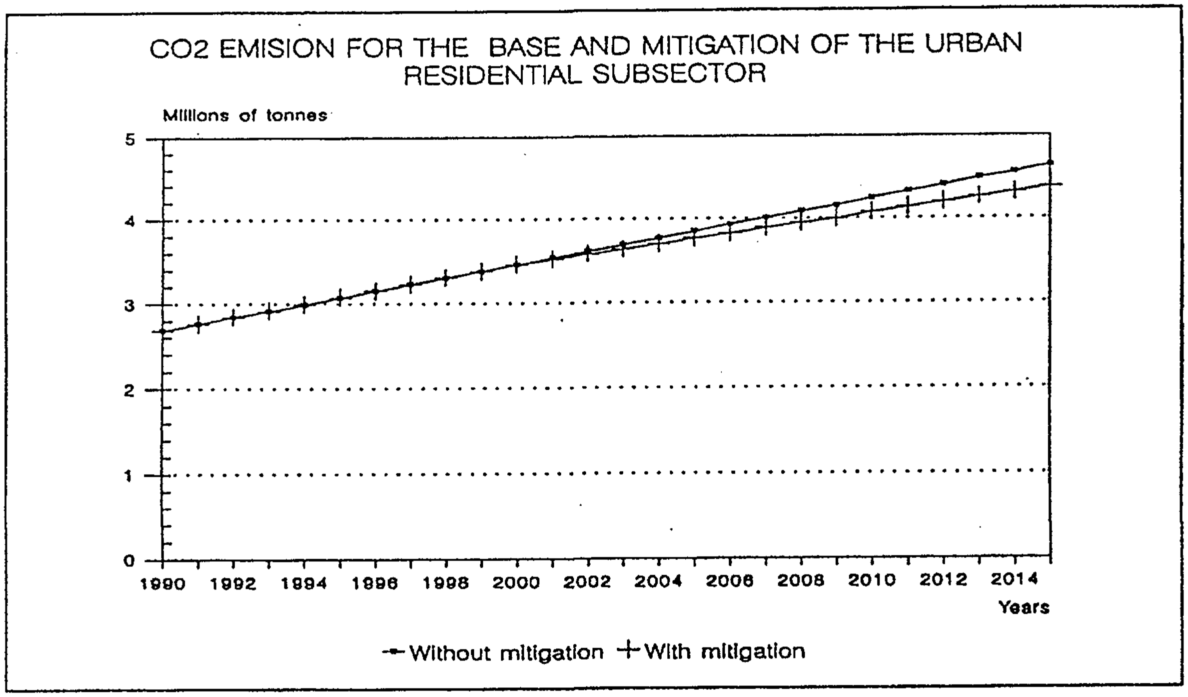

Fig. I.2.1 CO_2 emission for the base and mitigation scenarios of Urban Residential Sector.

I.2.1.1.2 Mitigation in the rural residential subsector

The Rural Residential Subsector basically uses firewood. This fuel produces a high level of CO_2 emission and it is use quite inefficiently. Due to the social reality and the lack of proper governmental policies, it is difficult to find a mitigation option for this case.

In the present study, we propose the use of LPG instead of firewood with a substitution of 2% each year since 1999 until get a reduction of 20% of the 1998 consumption in 2008.

This assumption is based on the return of the population who scaped from their land because of terrorism and will use LPG instead of wood. It is also based on the government policies aimed at the improvement of a better standard of life. The study about the use of wood cooks in a better way will continue.

Figure I.2.2 shows the mitigation options for the Rural Subsector. A reduction of 2.7 MMT of CO_2 (19.4%) in 2015 and a total mitigation of 31.3 MMT of CO_2 for the whole period (1990-2015) are obtained.

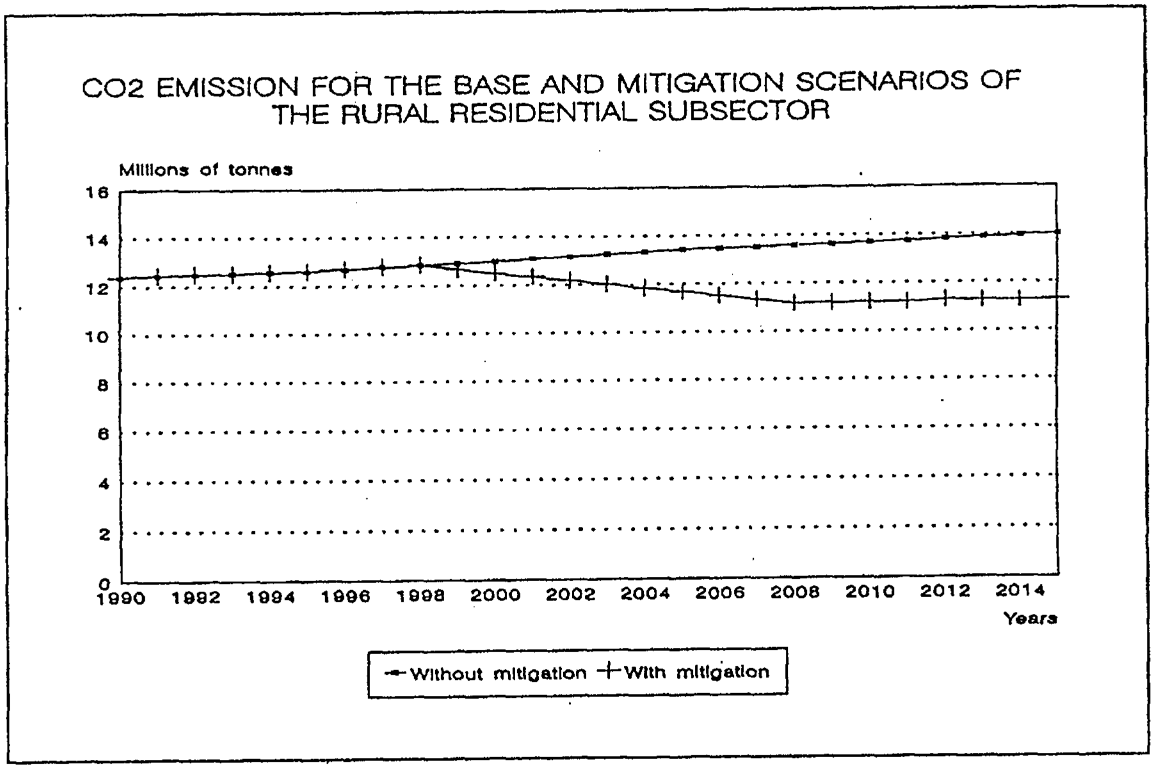

Fig. I.2.2 CO_2 emission for the base and mitigation scenarios of the Rural Residential Sector.

I.2.1.2 Transportation sector

The Transportation sector is the most important consumer of oil derivatives products. As a consequence, this sector is the major emitter. It accounting 37% of the total consumption without considering the emission by biomass consumption.

From the energy consumption viewpoint, the road transport is the most important in this sector. It is concentrated in big cities, particularly in Lima with a 66% for 1990. For this reason it has been considered to apply the mitigation option.

The assumptions for this study are:

a) The limit circulating time for automobiles and vans must be 18 years and for buses and trucks 16 years.

b) For the year 2015, the Urban transportation must be constituted by 20% of cars which use compressed natural gas (CNG), 10% of buses and small trucks.

c) The vehicles that exceeds the stipulated limit circulating time must to be replace or repaired by using better maintenance processes, in order to fullfil the stipulated regulations of the new ones.

d) The reference for the limit circulating time has been established according to the base year 1990, that is to say that, for the year 2008 the vehicles of 1990 must fulfill the control environmental regulations, if not they have to be removed.

The use of the electric train in Lima has not been considered, because it is necessary to know what will be the electricity generation origin for it. If this generation is thermal, there would be no GHG emission reduction. We have to take into account that this sector is a complex one because of the diversity of the vehicles inventory.

Since data has not been properly structured for this kind of studies, it is necessary to make a great effort to specify and apply the mitigations options in this sector.

Figure I.2.3 shows the mitigation option for the transportation sector. In 2015, a reduction of 4.7 MMT of CO_2 (23%) and a total reduction of 52.88 MMT in the whole period of study (1990-2015) are achieved.

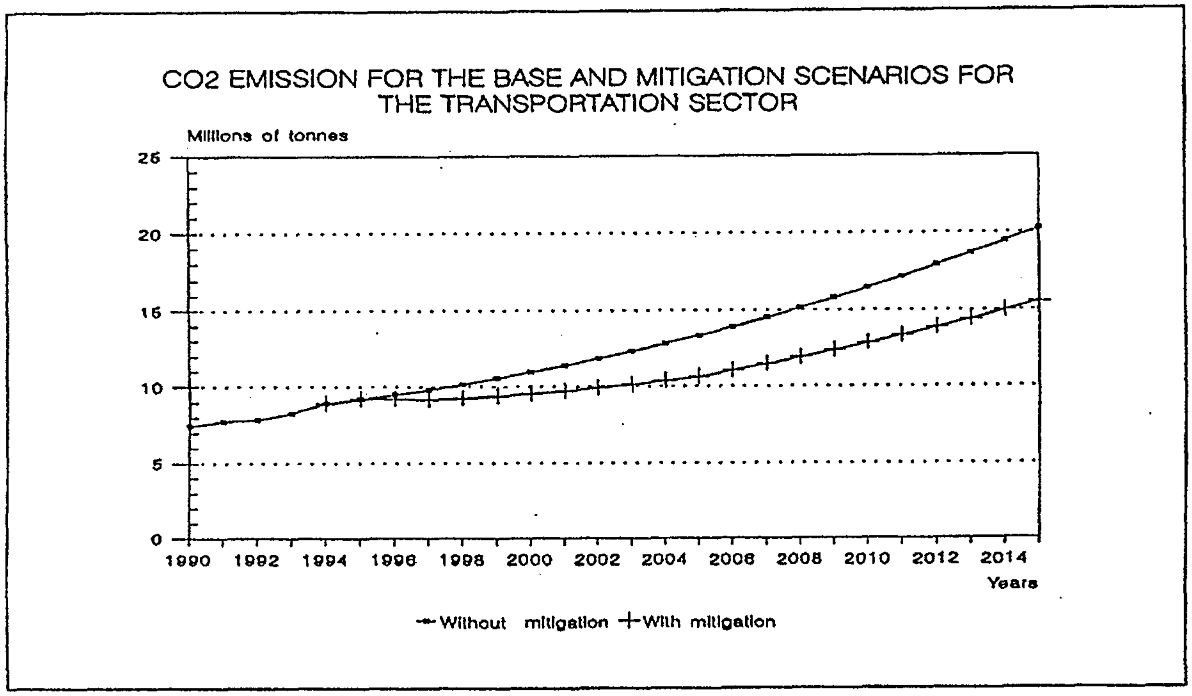

Fig. I.2.3 CO_2 emission for the base and mitigation scenarios for Transportation sector.

I.2.1.3 Industrial sector

The Industrial Sector plays an important role in the development of the country that is why the governmental policies are aimed at its development, conscious of it's importance, we hope a high growth in the future.

Due to its characteristics, this sector requires new technologies as well as modernization of the current equipment. The implementation of new technologies and the Peruvian industrial modernization process will lead to energy savings. In the Peruvian Industry, the direct heat generation represents the major consumption. Residual oil , diesel and wood are used in the direct heat generation. Wood is mainly used in the food industry. For these reasons, the mitigation option has been applied in the direct heat generation in this sector.

The assumptions for this sector are:

a) From 2001 to 2015, wood consumption must decrease in 30 % replacing it with natural gas. We assume that in 2000 Camisea gas will be already exploited.

b) With the Industry modernization since 2001, the increase of residual oil use will be only 1% using technologies similar to the existing ones and natural gas technology, it would be 2% of the total growth. The remaining growth will continue using residual.

c) The proposed scenario for Diesel oil use is the same as the one proposed for Residual

In this scenario, the use of natural gas has not been proposed in great scale because of the lack of economic studies about its exploitation.

Figure I.2.4 shows the mitigation option for the industrial sector, it can be observed that,it will be possible to reduce 6.6 MMT of CO_2 (31%) in 2015 to get a total reduction of 47.55 MMT in the whole period of study (1990-2015).

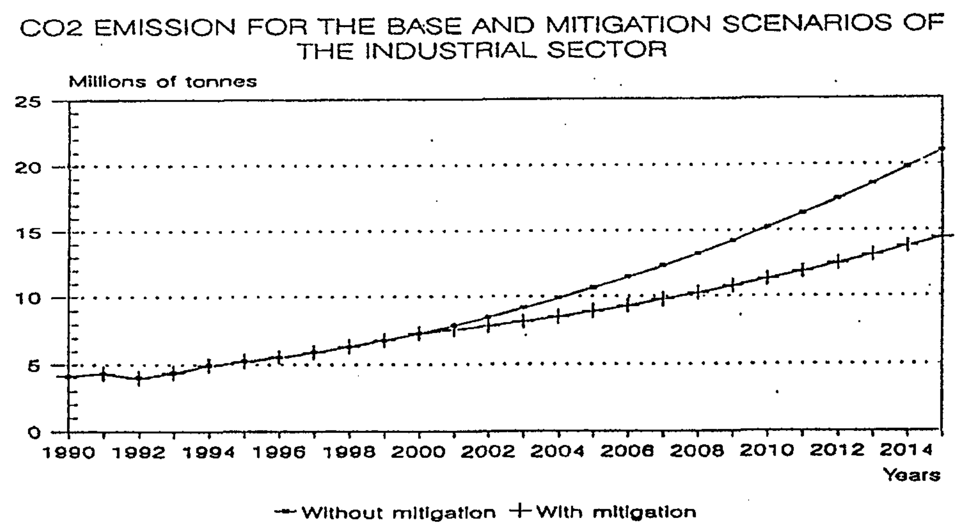

Fig. I.2.4 CO_2 emission for the base and mitigation scenarios of the Industrial sector.

I.2.1.4 Electricity generation

In the conversion activity of primary energy resources into secondary ones, we have focused the electricity generation mitigation because it is the most important among the fuels and CO_2 emission consumption. In Peru, the electricity system is composed by three electricity systems: the North Central Interconnected Electric System, the South West Interconnected Electric System , and the Isolated Electric System.

The North-Central Electric System is the bigger, accounting 63% of the total national installed capacity 4195 MW for 1990, from which 75.21% was hydraulic and 24.79% thermal.

The Wien Automatic System Planning Package (WASP) was used to make the electric planning of this activity. Two scenarios wereconsidered in this study: The base scenario and the mitigation one. In the first case the electric planning was made without considering the Camisea gas used in the plants proposed by the Ministry of Energy and Mining in its referential plan. In the second case, it has been considered the new technologies for plants of combined cycle gas assuming that the Camisea gas will be exploited from 2000.

Figure I.2.5 shows our mitigation option for the electricity generation. A reduction of 3.3 MMT of CO_2 (17%) in 2015 and a total reduction of 31.49 MMT in the whole period of study (1990-2015) are achieved.

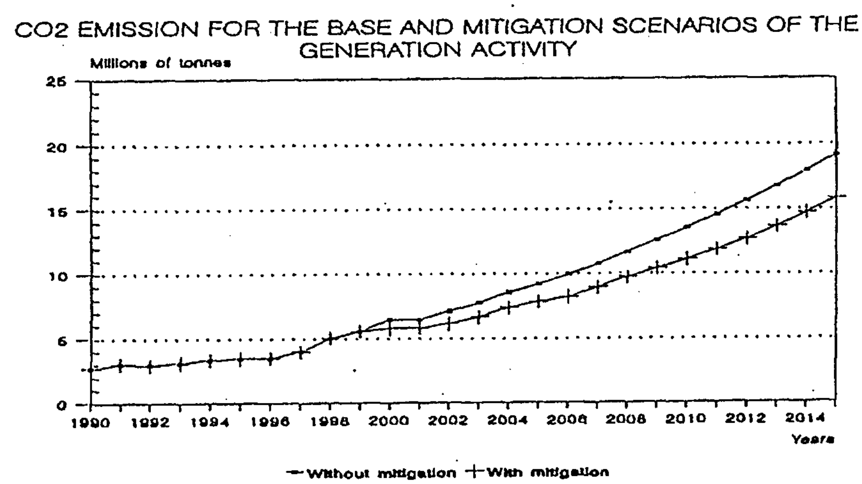

Fig. I.2.5 CO_2 emission for the base and mitigation scenarios for the generation activity.

I.2.2 TOTAL CO2 EMISSION

This section presents a summary of the total CO_2 mitigation for the energy sector. Table I.2.2 shows the total CO_2 mitigation for the base and mitigation scenarios. Figure I.2.6 presents the result of the mitigation proposal for the present study. In the base scenario, the emission increase from 35.76 to 100.80 MMT of CO_2 in the period between 1990 and 2015. In the mitigation scenario, the emission increases from 35.76 to 83.24 MMT, as a result of this, in 2015 a total reduction of 17.6 MMT of CO_2 (17.4%) is achieved.

Figure I.2.7 presents the total emission with and without mitigation for the whole period of study (1990-2015). A total reduction of 165 MMT of CO_2 is achieved. This is an important contribution to the solution of the global warming problem by Peru.

TOTAL EMISSION
UNITS: MILLIONS OF TONNES

Years	Without Mitigation	With Mitigation
1990	35.76	35.76
1991	37.13	37.08
1992	36.76	36.72
1993	38.41	38.31
1994	40.68	40.49
1995	41.88	41.66
1996	42.94	42.66
1997	44.78	44.16
1998	47.11	46.24
1999	49.16	47.77
2000	51.62	49.08
2001	53.31	49.98
2002	55.72	51.20
2003	58.24	52.70
2004	61.05	54.64
2005	63.79	56.18
2006	66.74	57.91
2007	69.80	60.14
2008	73.29	62.53
2009	76.74	65.03
2010	80.37	67.68
2011	84.19	70.48
2012	88.10	73.40
2013	92.22	76.48
2014	96.40	79.78
2015	100.80	83.24

TableI.2.6 Total CO_2 emission for the base and mitigation scenarios

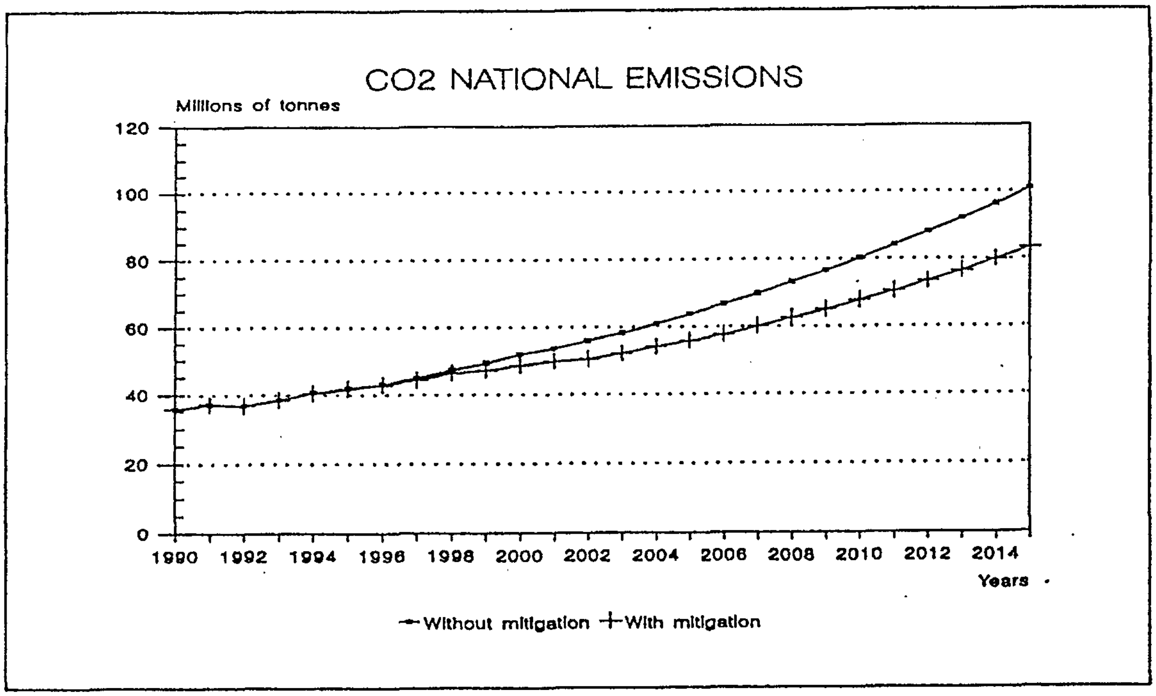

Fig. I.2.6 Total CO_2 emission with and Without mitigation.

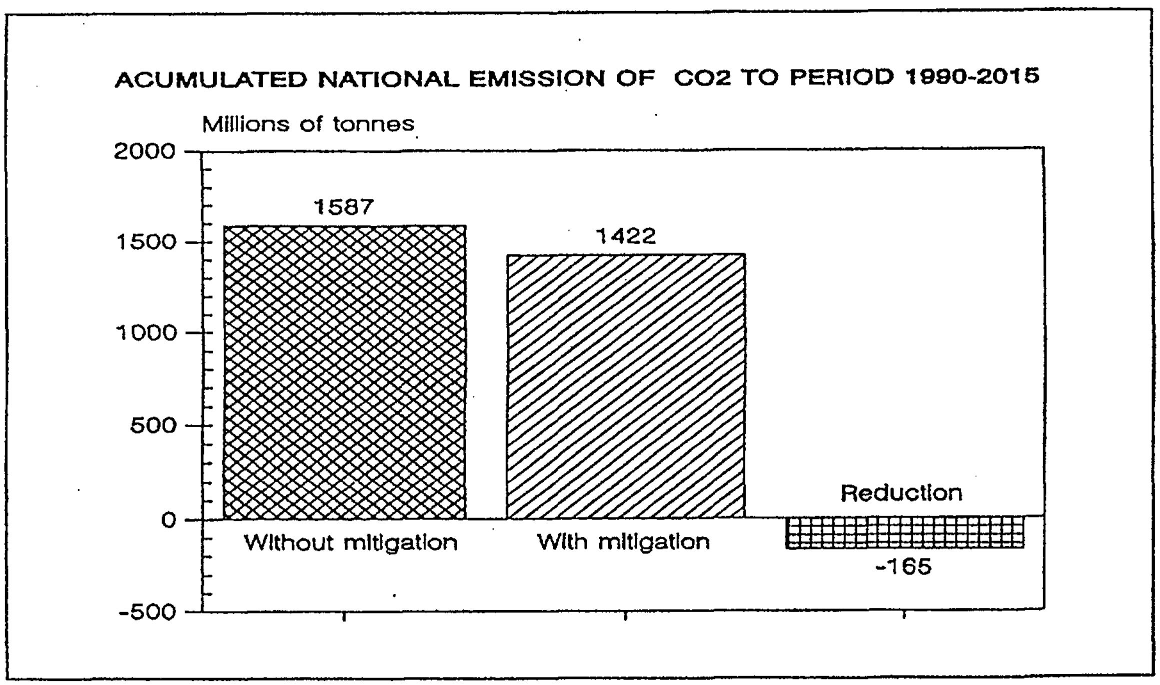

Fig. I.2.7 Total CO_2 emission with and without mitigation for the whole period of stufy (1990-2015).

I.3 CONCLUSIONS AND RECOMMENDATIONS

The base and mitigation scenarios were elaborated by using the ENPEP model and assuming an annual growth average by sectors of 5.1% of the total GDP and a total population growth rate of 2.26% and 0.45% in the Rural population. The emissions for this base scenario increase from 35.76 to 100.80 MMT of CO_2 in the period between 1990 and 2015. For the mitigation scenario the emissions increase from 35.76 to 83.24 MMT of CO_2 for the same period. As a result of this, a total reduction of 17MMT of CO_2 is achieved in 2015. The total CO_2 reduction for the whole period of study (1990-2015) is 165 MMT of CO_2. This results indicate that, if the government designs policies aimed at the realization of the present proposal, it will contribute to the mitigation of the GHG and the solution of the earth warming problem.

The Peruvian Energy Network has been structured. This structure has great importance for the energy planning and environmental preservation studies. Therefore the ENPEP model has been analyzed in an adequate form. This model was developed by the Argonne National Labotratory (ANL) USA and is being applied by the countries which take part in the Country Studies Program of the USA as well as for other countries.

The mitigation options have been applied in the following sectors: Industrial, Residential, Transportation and Electricity Generation activity. The Residential Sector was divided in the following subsectors: Urban and Rural Residential.

The Urban Residential uses mainly kerosene, assuming that the Camisea gas will be exploited since 2001, it will be substituted with natural gas. As a result of this, in 2015 a reduction of 0.3 MMT of CO_2 and a total reduction of 1.97 MMT for the whole period of study (2001-2015) are achieved.

In the Rural Residential Subsector, a total reduction of 31.3 MMT of CO2 is achieved for the period from 1999 to 2015, making a replacement of 20% of firewood used in 1998 with LPG in the period in between 1999-2008. From 1999 the new firewood demand must to be replaced with LPG.

Taking into account the limit circulating time of 18 years for automobiles and 16 years for buses and trucks, a total mitigation of 52.84 MMT of CO_2 is achieved, in the transport sector during the whole period of study (1990-2015). Therefore, 20% of the automobiles that use gasoline or diesel must be replaced with comprissed natural gas automobiles and 10% of buses must to be replaced by gas vehicles.

With the implementation of new tchnologies and the modernization of the existing equipment, a total reduction of 47.55 MMT of CO_2 is achieved in the Industrial sector. The use of diesel and residul must be replaced with gas in 2% of the new energy demand. The equipment efficiency must be improved.

A total mitigation of 31.49 MMT of CO_2 is obtained in the Electricity Generation between 2000 and 2015. This reduction is obtained in the North Central interconnected Electricity system with plants of combined cycle gas instead of Residual and Diesel plants.

The present study is the first one about the mitigation of the most important GHG, CO_2 in the energy sector of Peru. However, it requires an economic analysis in order to obtain the costs and profits of the present proposal. We did not have available data to predict the costs evaluation.

This study has been carried out mainly by UNI and IPEN which were in charge of its development as well as other institutions with the aim to reach the goals presented in the foregoing pages. It is necessary to continue with the achievements of this kind of studies and its instrumental implementation in order to carry out the mitigation proposals.

The present study is a referencial document for the goverment, so it can determine accurately the environmental policies at long term

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APPENDIXES

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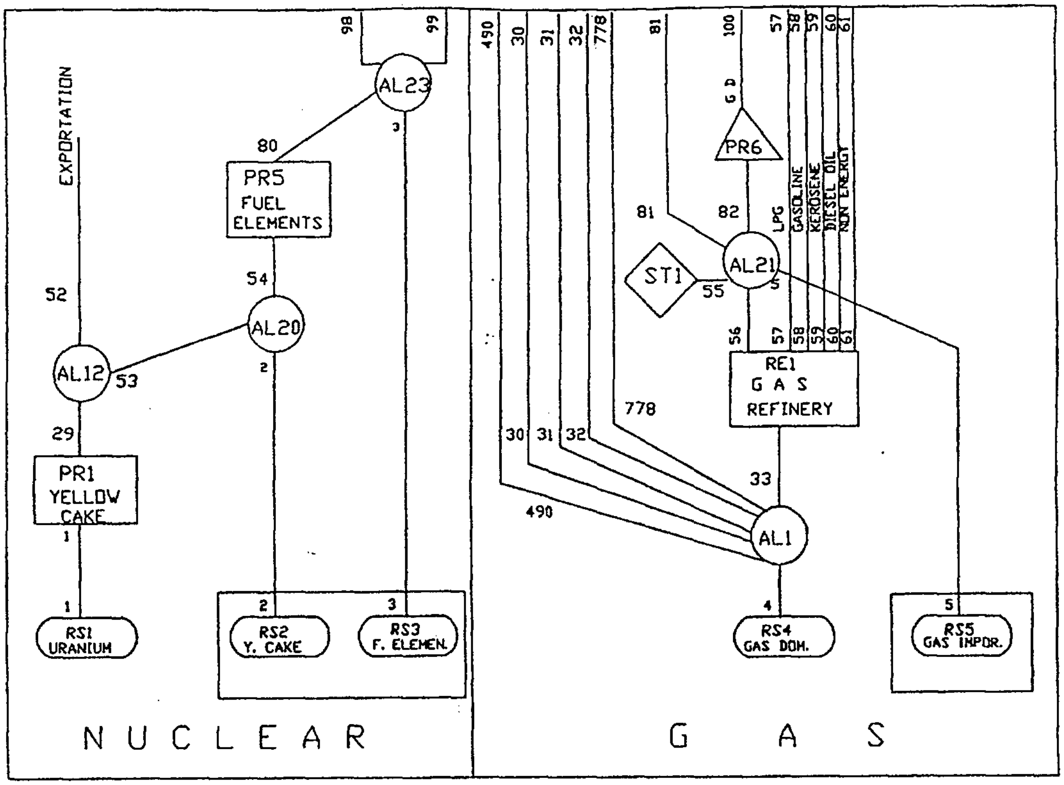
A. APPENDIX A

This Appendix presents the Peruvian network which comprises the energy resources from their extraction to their end use. The ENPEP model requires the integral visualization and diagnosis of the energy system of the country, region, city or area to which the energy plan as well as enviromental preservation will be applied, such as: polluting gas mitigation, GreenHouse gases mitigation and others degrading agents of water, air and soil. This model allows to carry out mitigation studies about forestation, agriculture and changes in the use of land in the sector reffered as "non energy sector".

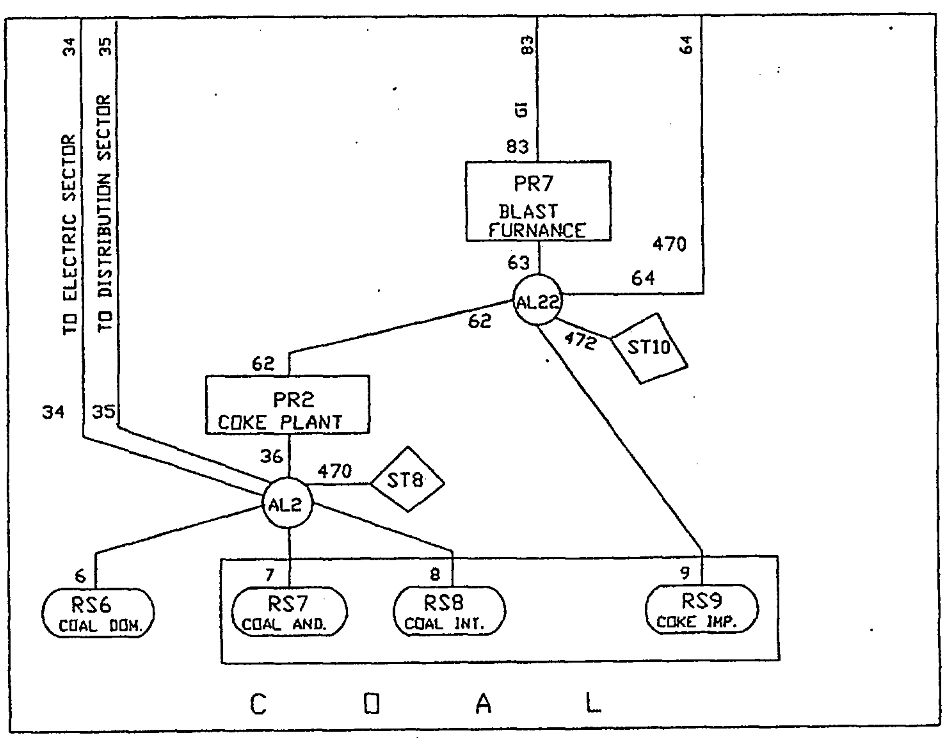
The energy network presented in this appendix contains the country integral energy network which has been used to elaborate the base scenario (without mitigation) and the mitigation scenario for the following sectors: Residential, Transportation, Industrial and Electricity Generation System.

The energy network presents the energy system by blocks which are interconected by a numerical identification that integrates the whole system. In the parcial views, we have the depletable energy resources (Nuclear, coal, oil etc.), the renewable energy resources (Hydroenergy, solar , eolic, biomass, wood, bung, bagasse etc.), the interconected and isolated electricity systems, the views of how the fuels and energy resources are distributed to the demand sectors and finally the demand sectors: Transportation, Residential, Industrial, Mining, Fishing, Agropecuarian, Agroindustrial, Commercial, Public Services and Exportation. Each sector shows respectively its way of energy use.

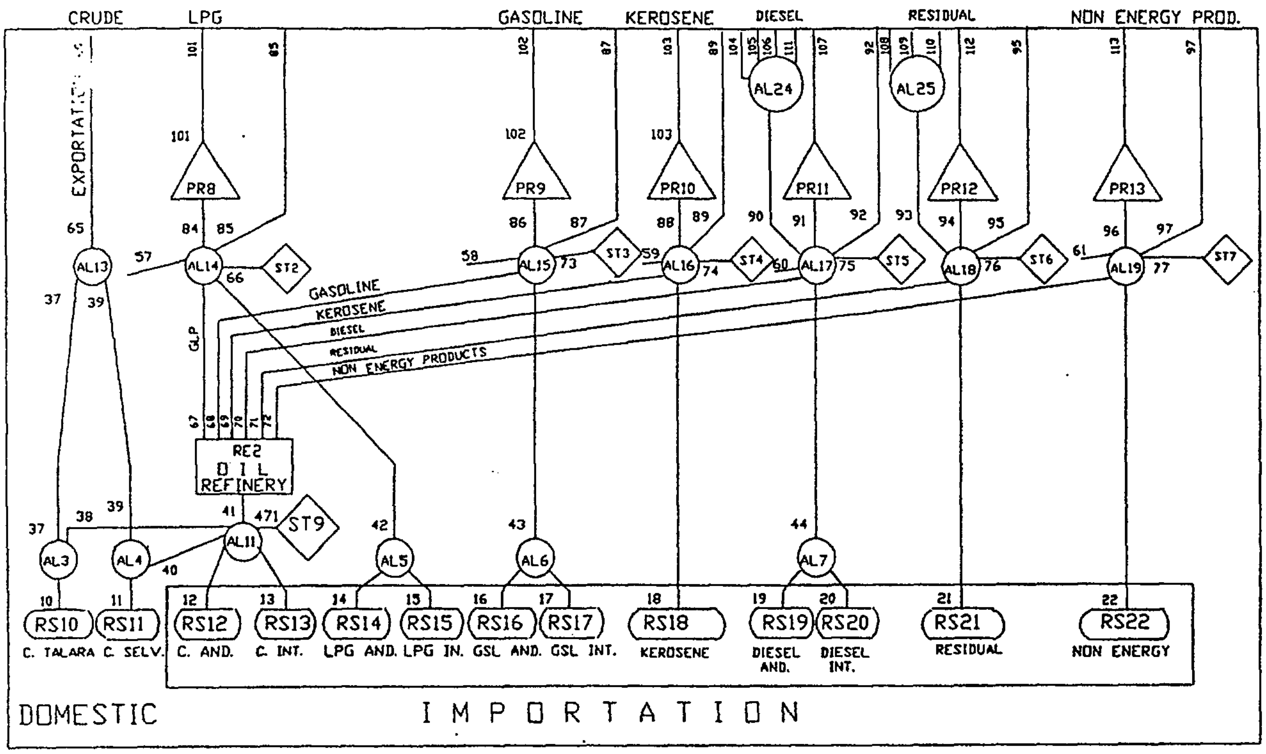
In the present study, the energy costs and mitigations which are related to the economic development as well as the population growth, have been evaluated. We have considered mainly the proved and probable reserves, taxes, technologies, production capacities (transformation), new technologies, fuel replacement, storage, transportation as well as market elasticities. The symbols used in the energy network are shown in Appendix B.



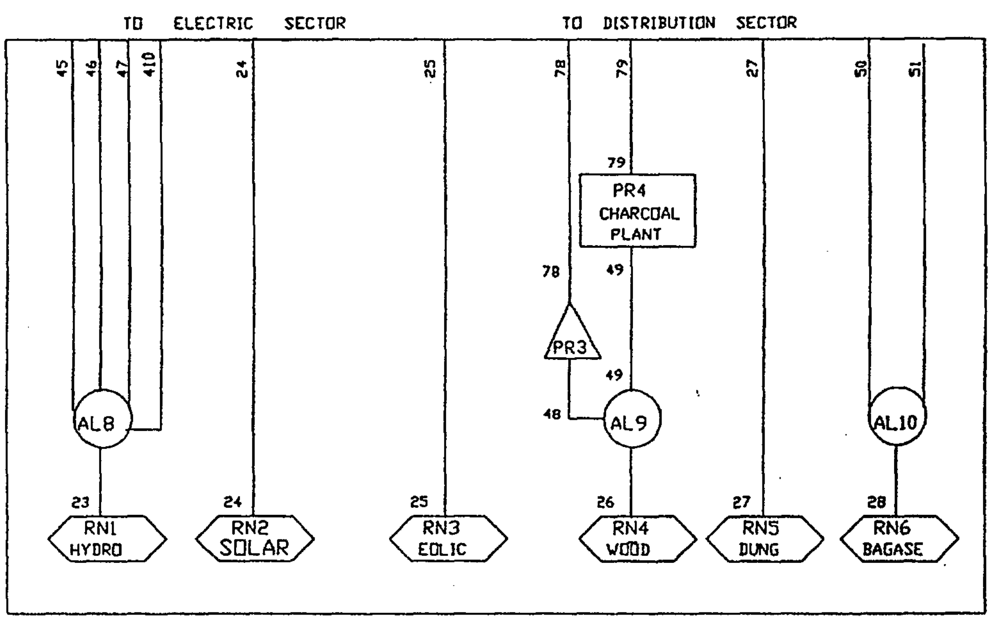
FUCTURE NUCLEAR ENERGY AND GAS EXPLOTATION



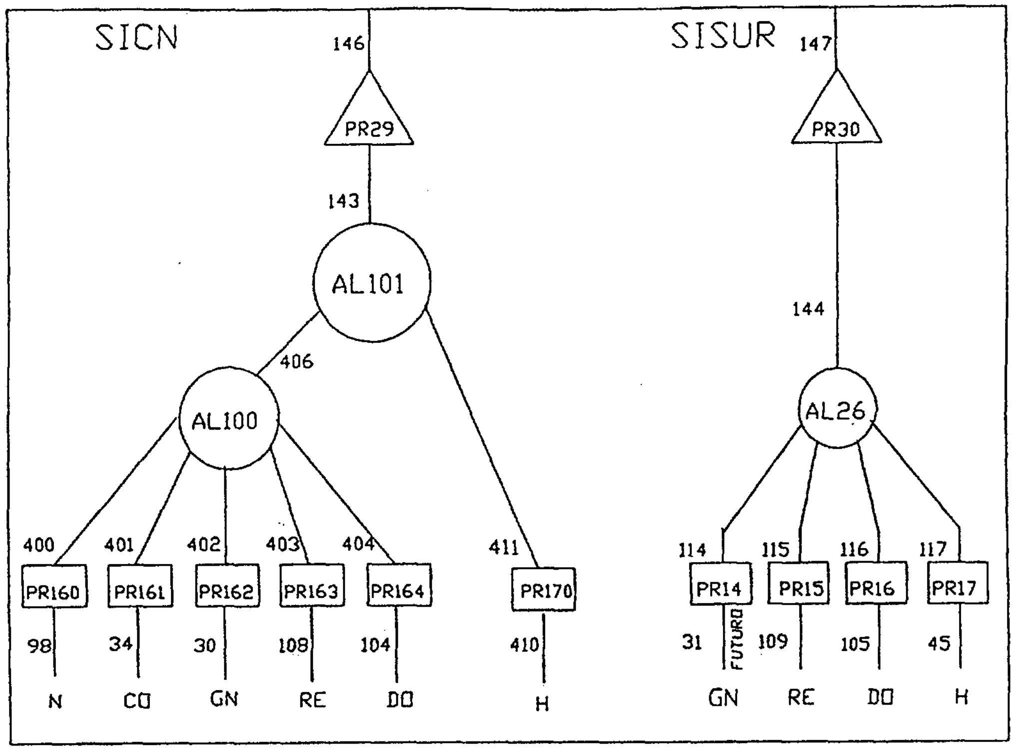
COAL AND COKE RESOURCES



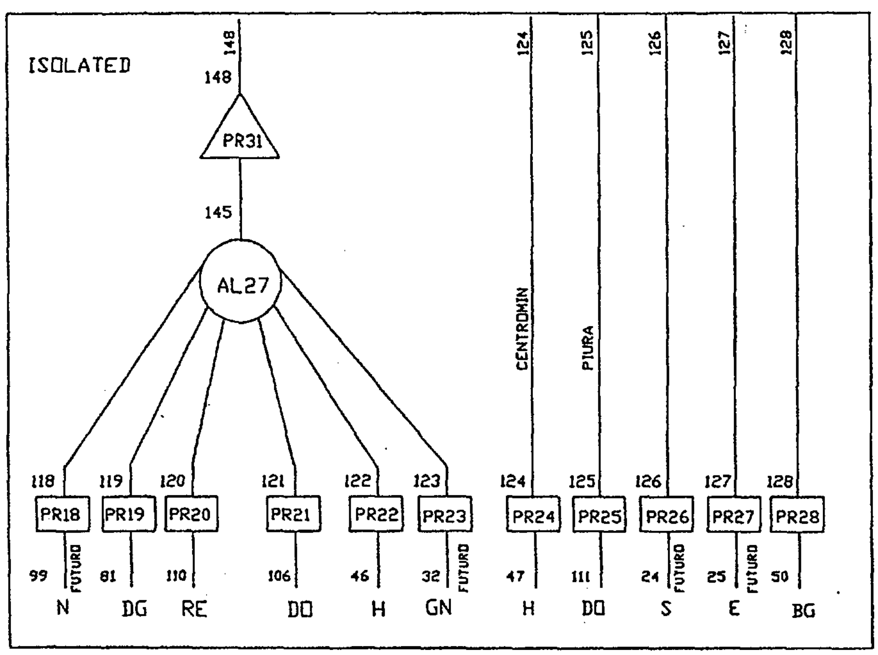
OIL RESOURCE



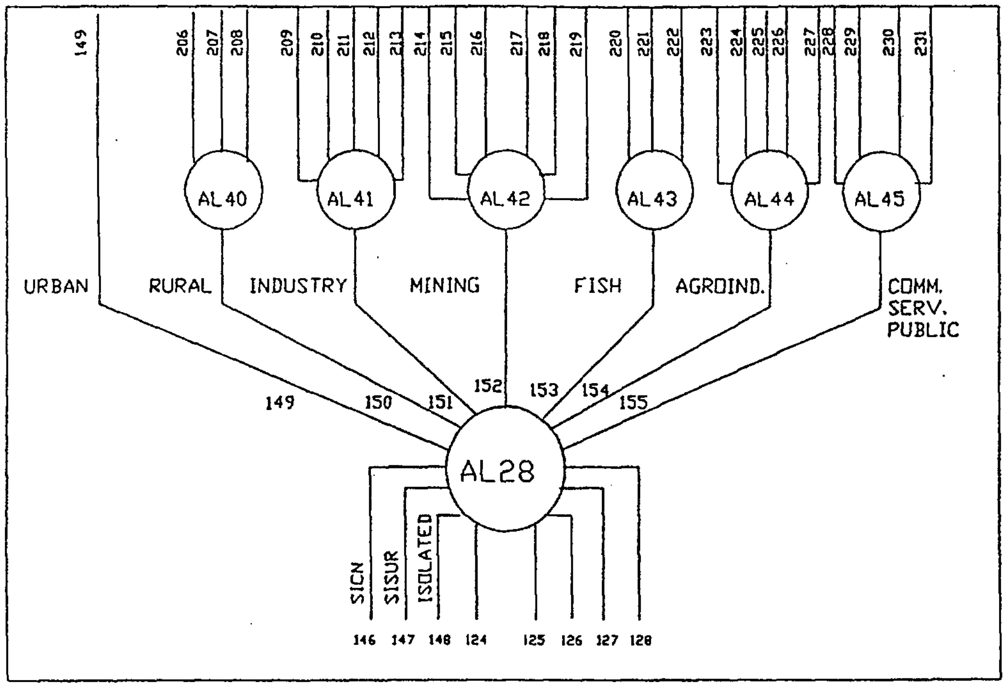
RENEWABLE RESOURCES



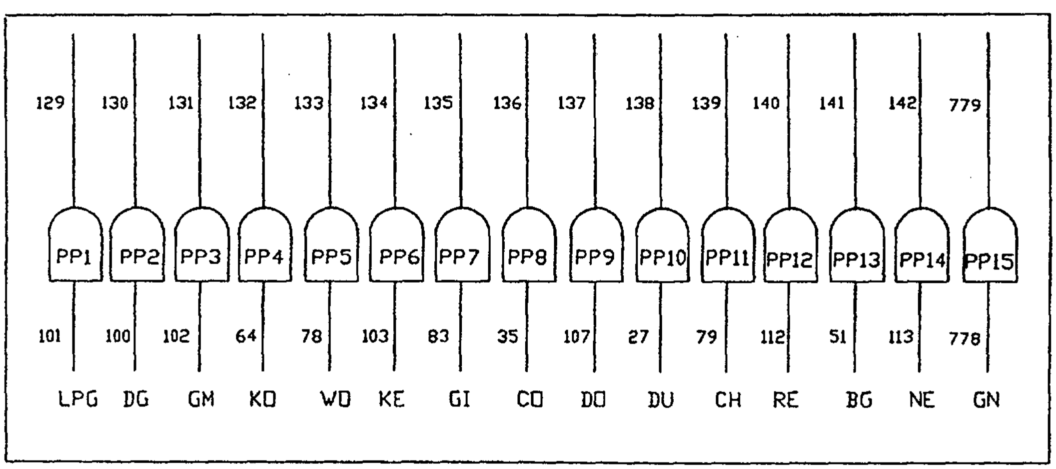
INTERCONNECTED CENTRAL NORTH AND SOUTH ELECTRIC SYSTEMS



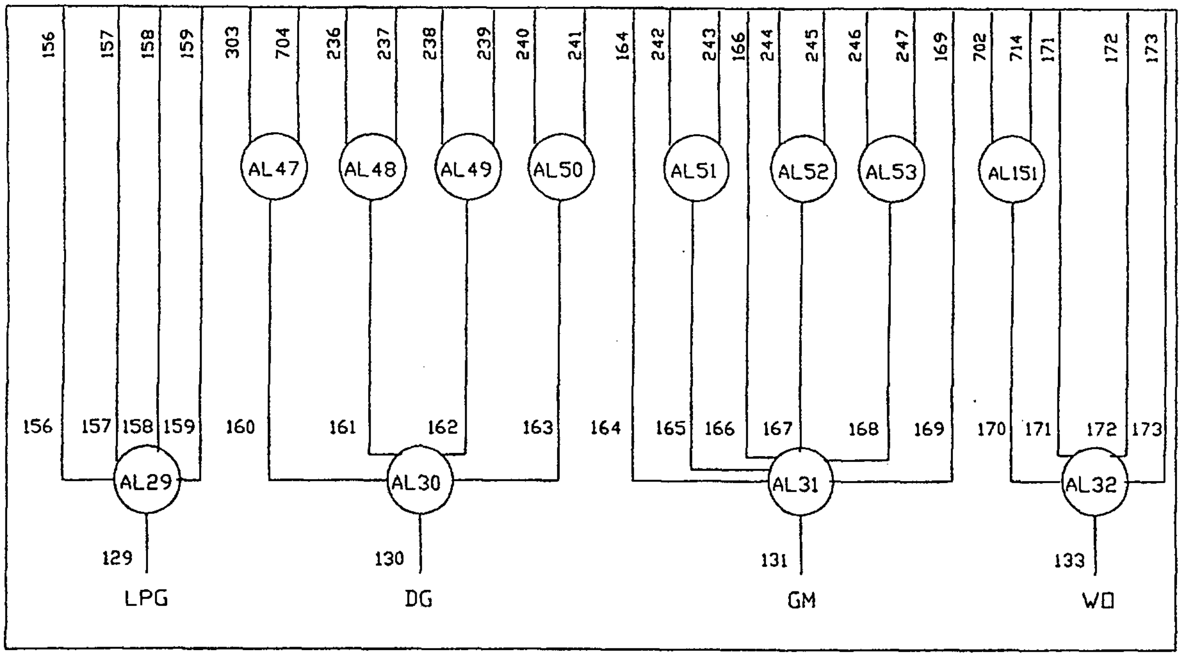
ISOLATED ELECTRIC SYSTEM



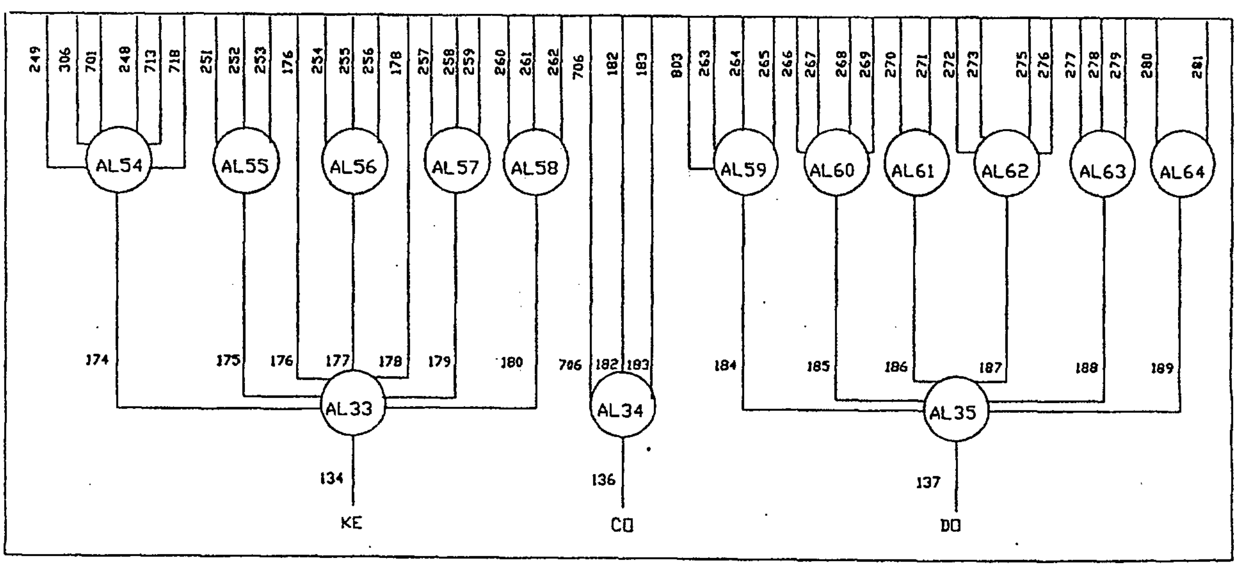
DISTRIBUTION OF ELECTRICITY TO DEMAND SECTORS



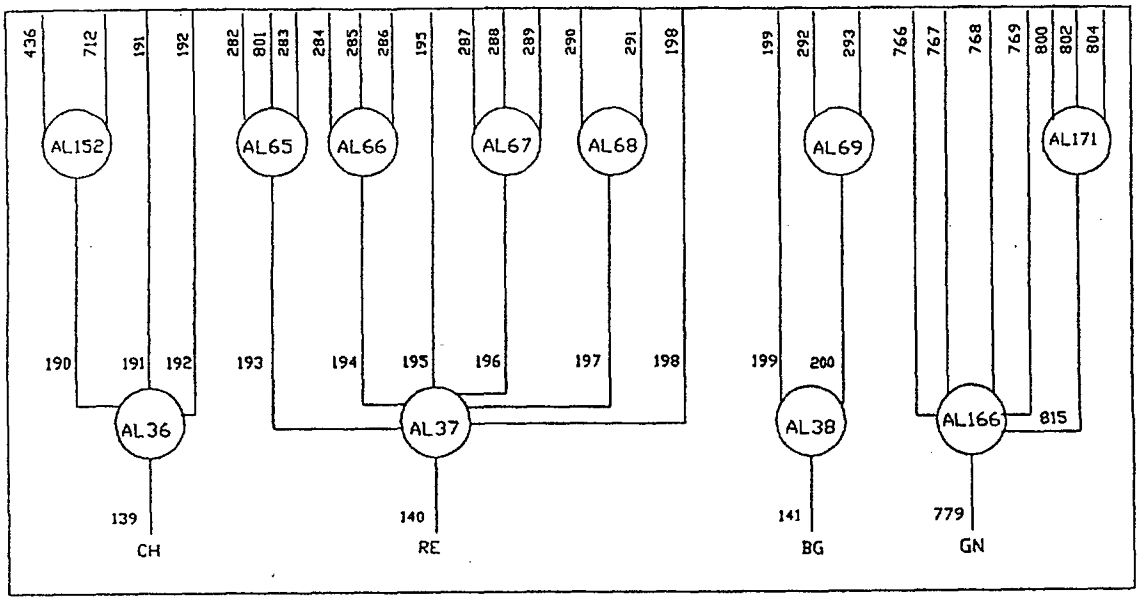
PRICES ANALYSIS



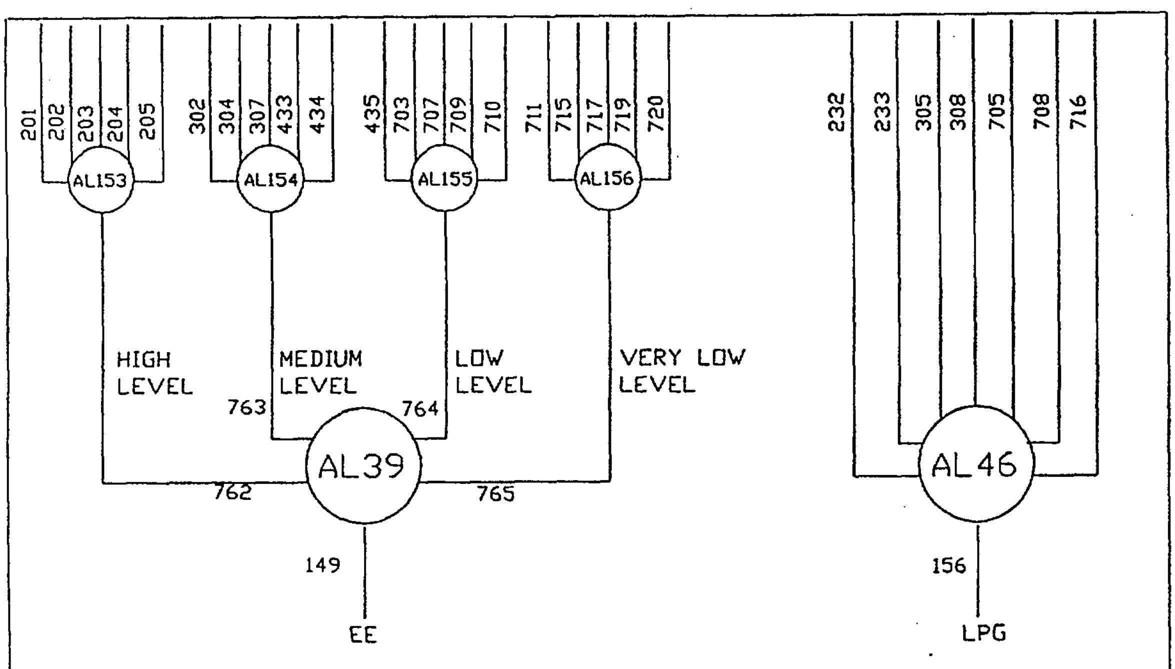
DISTRIBUTION SECTION



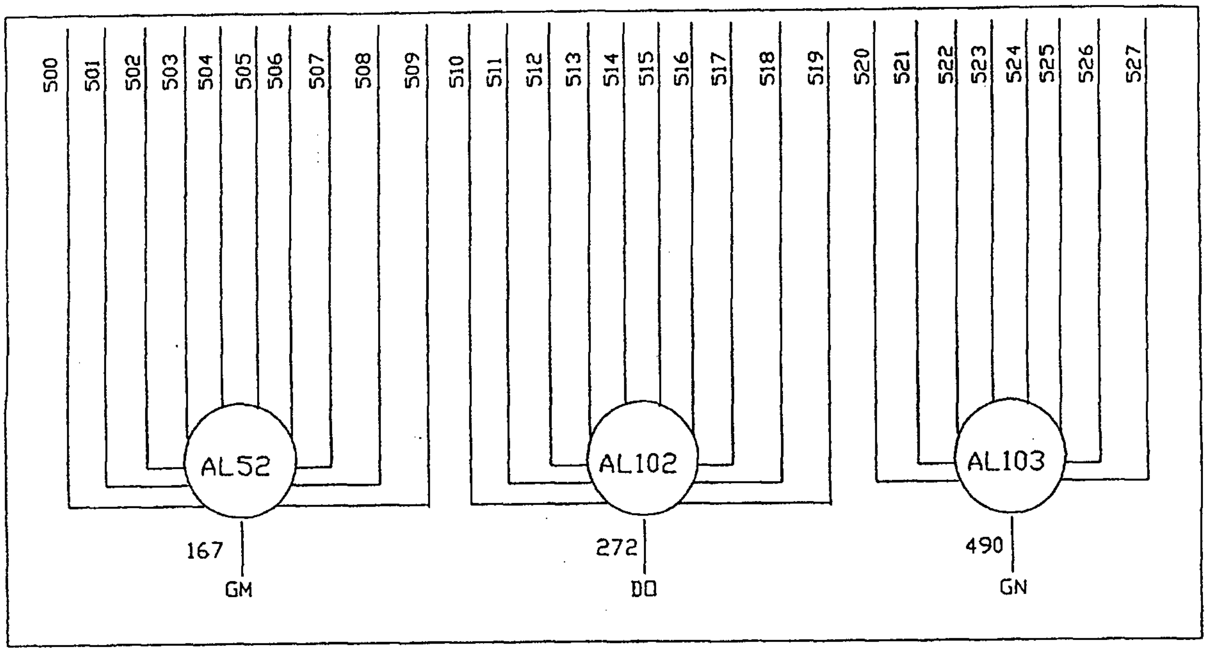
DISTRIBUTION SECTION



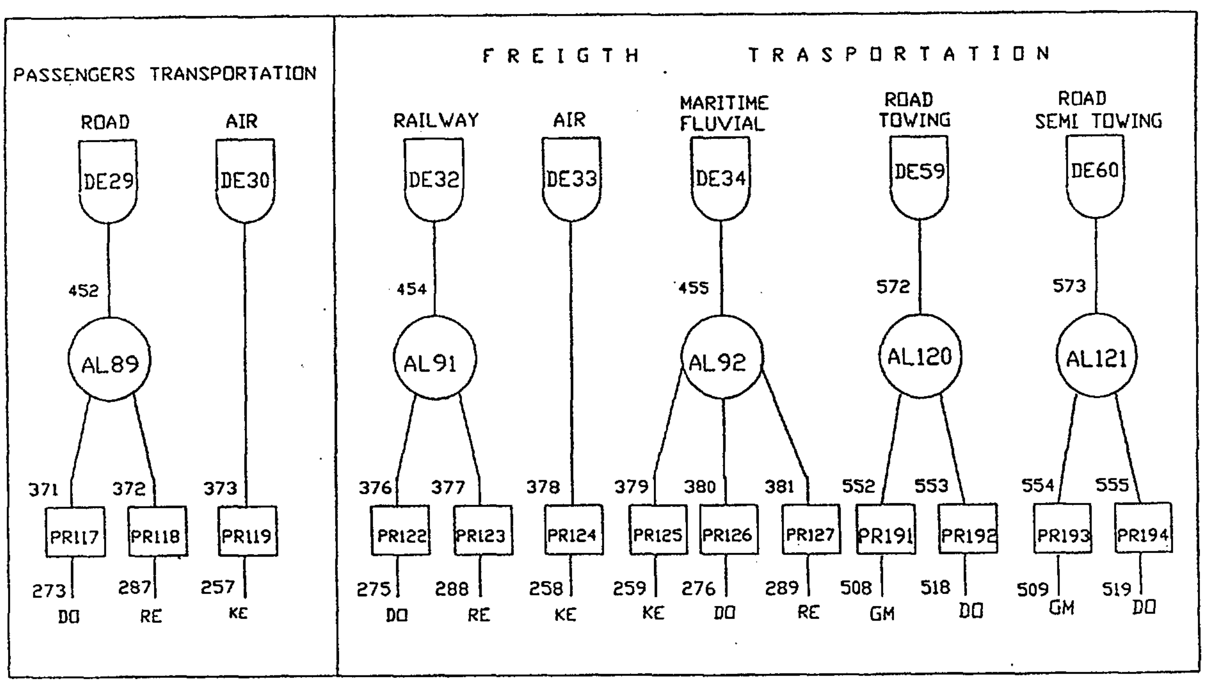
DISTRIBUTION TO DEMAND SECTOR



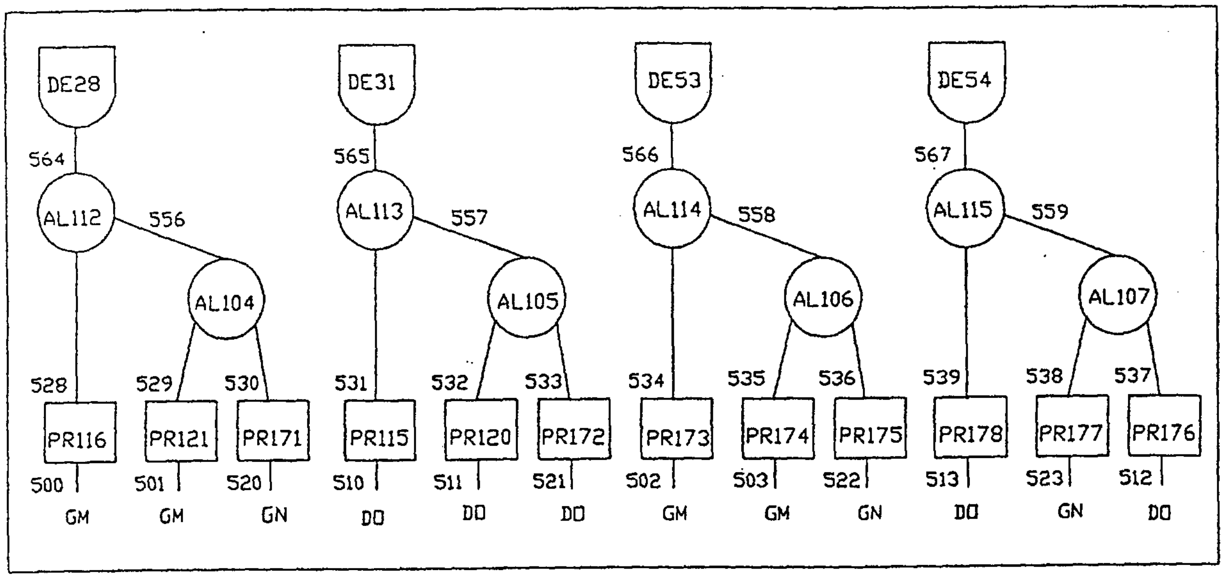
DISTRIBUTION TO URBAN SECTOR



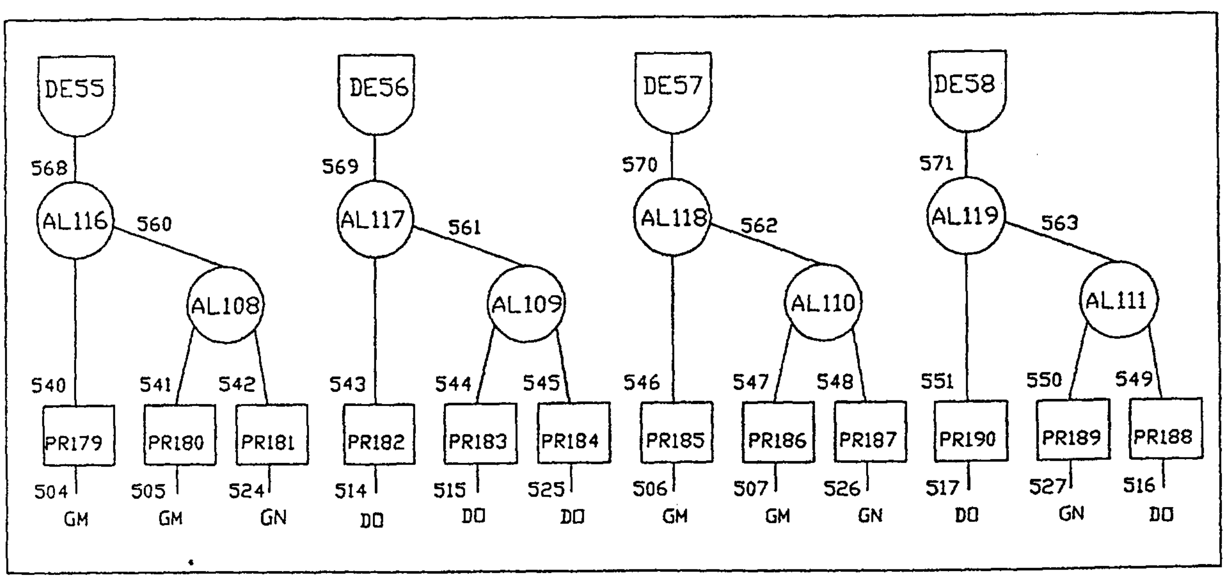
DISTRIBUTION TO ROAD TRANSPORT SECTOR



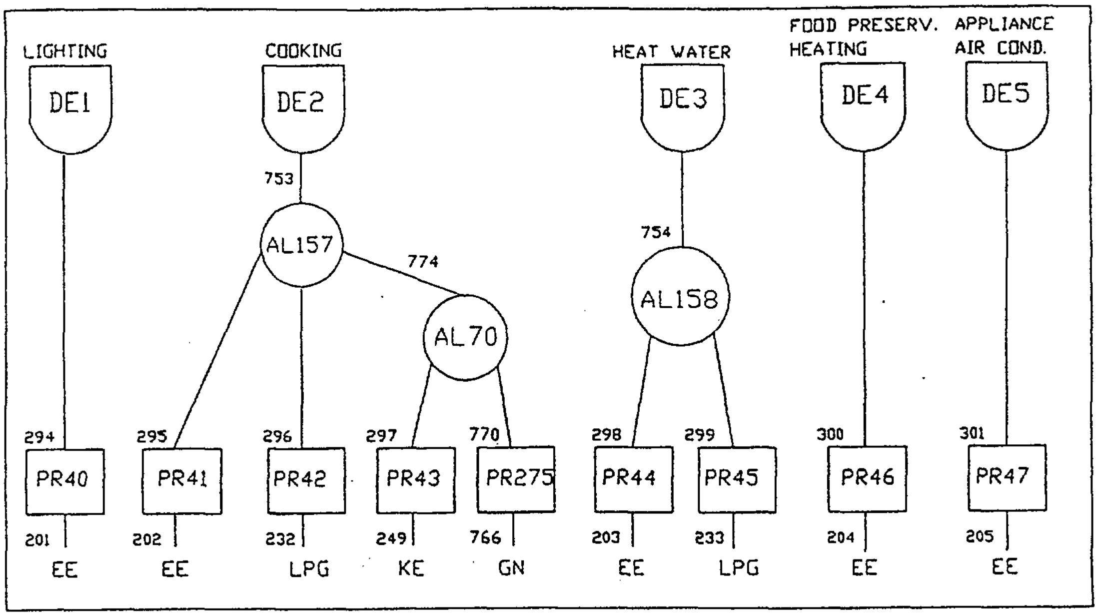
TRANSPORTATION SECTOR



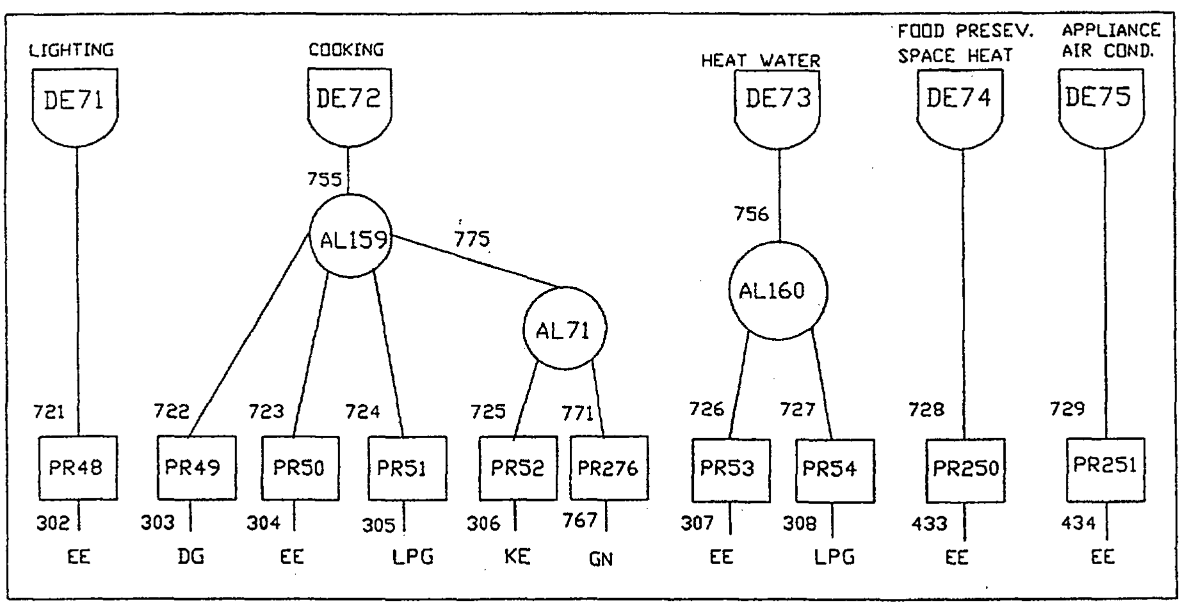
TRANSPORTATION SECTOR



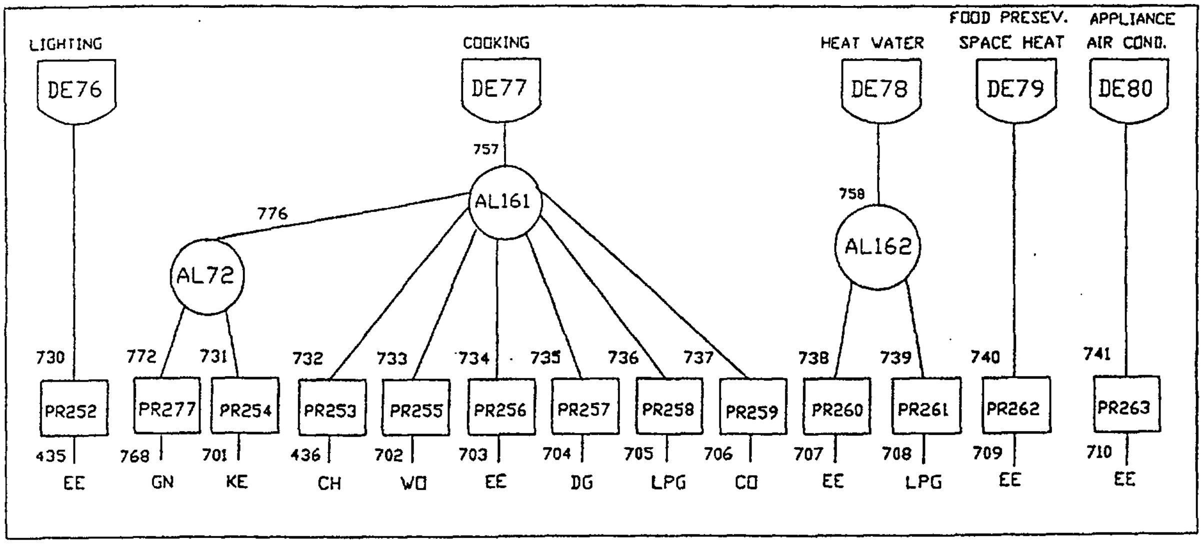
TRANSPORTATION SECTOR



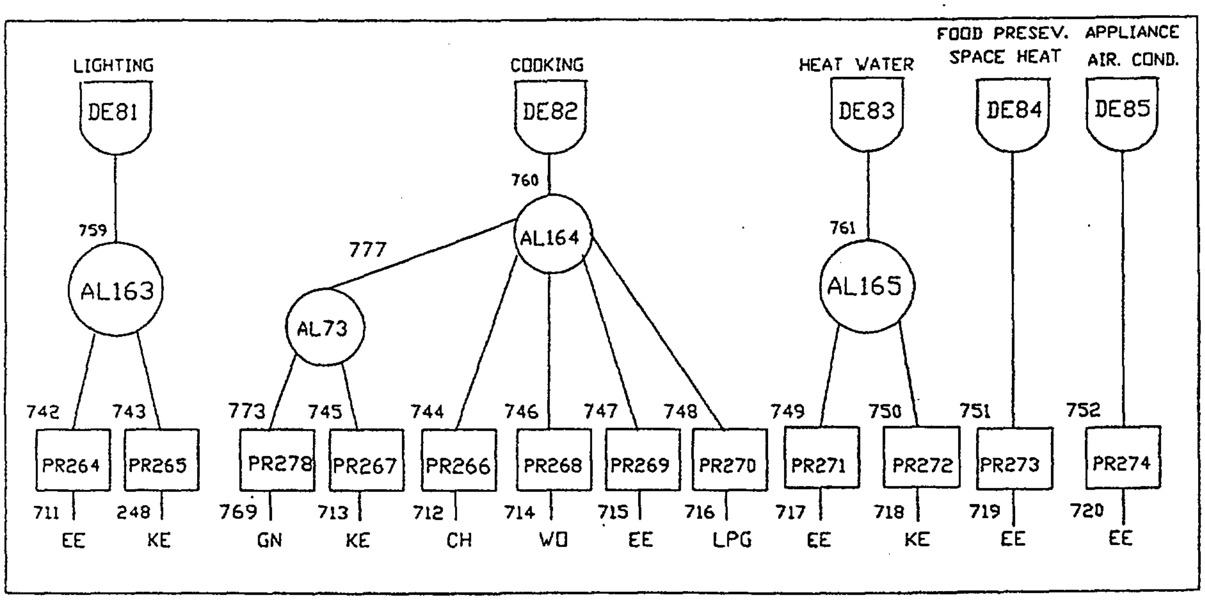
HIGH LEVEL URBAN SECTOR



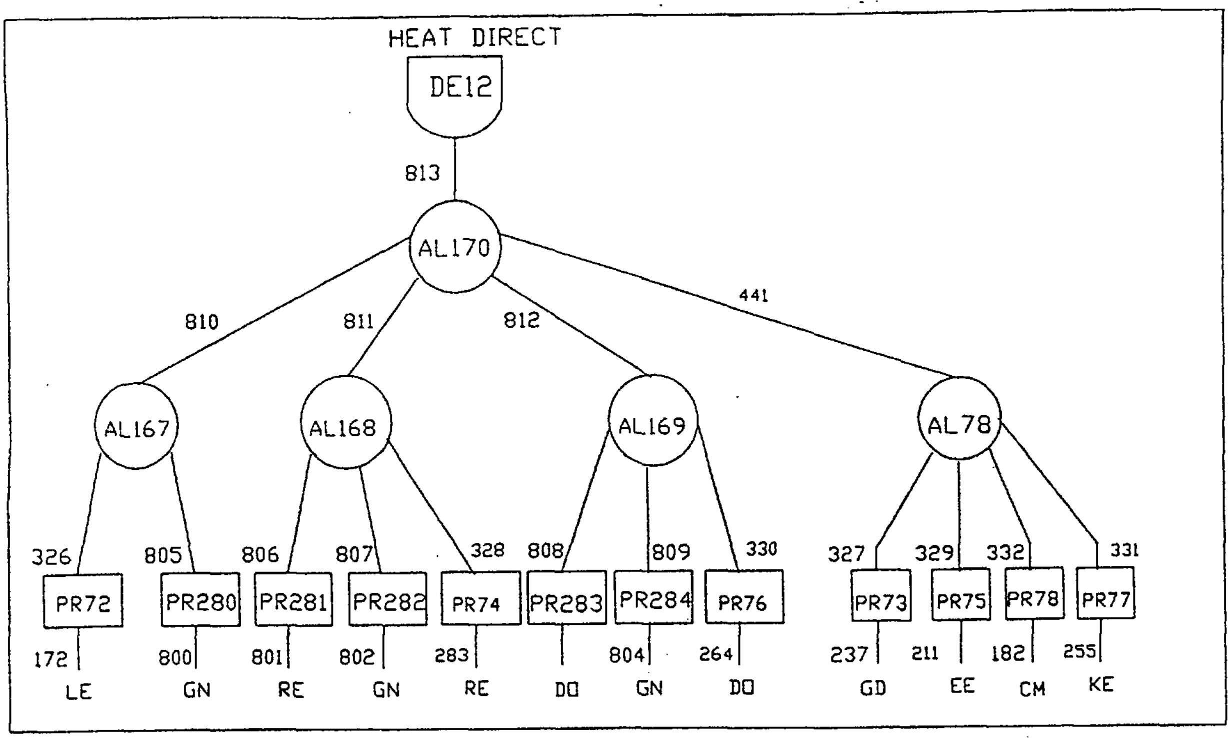
MEDIUM LEVEL URBAN SECTOR



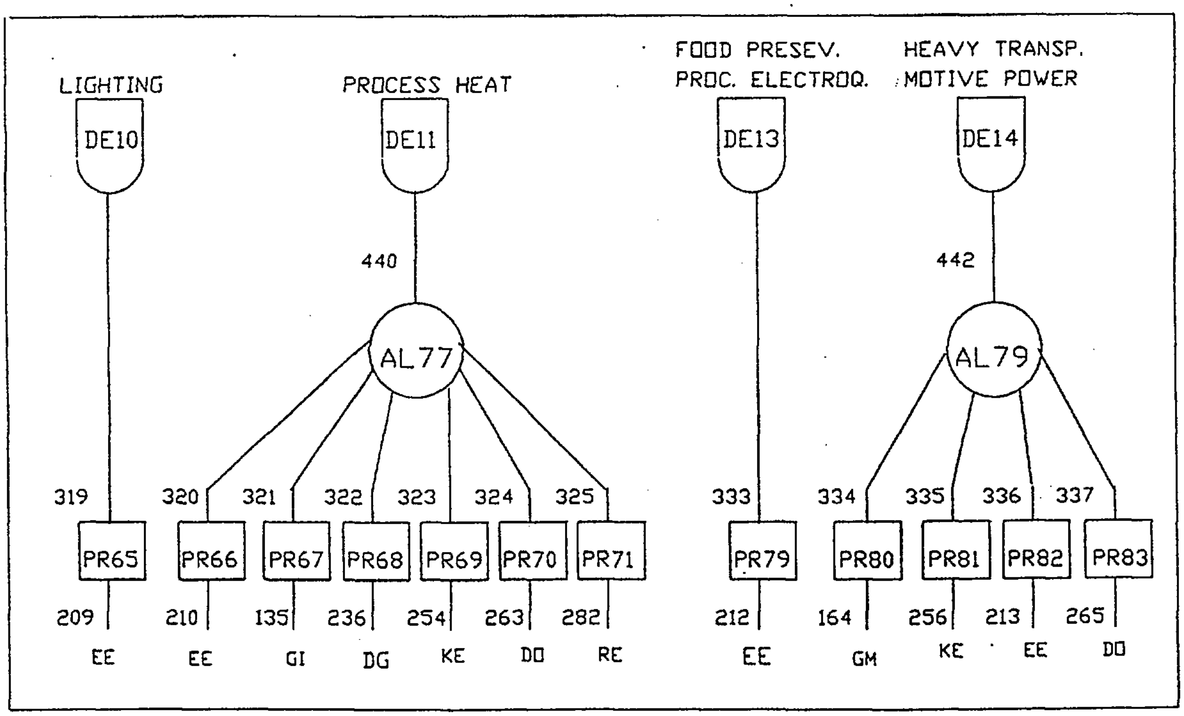
LOW LEVEL URBAN SECTO



VERY LOW LEVEL URBAN SECTOR

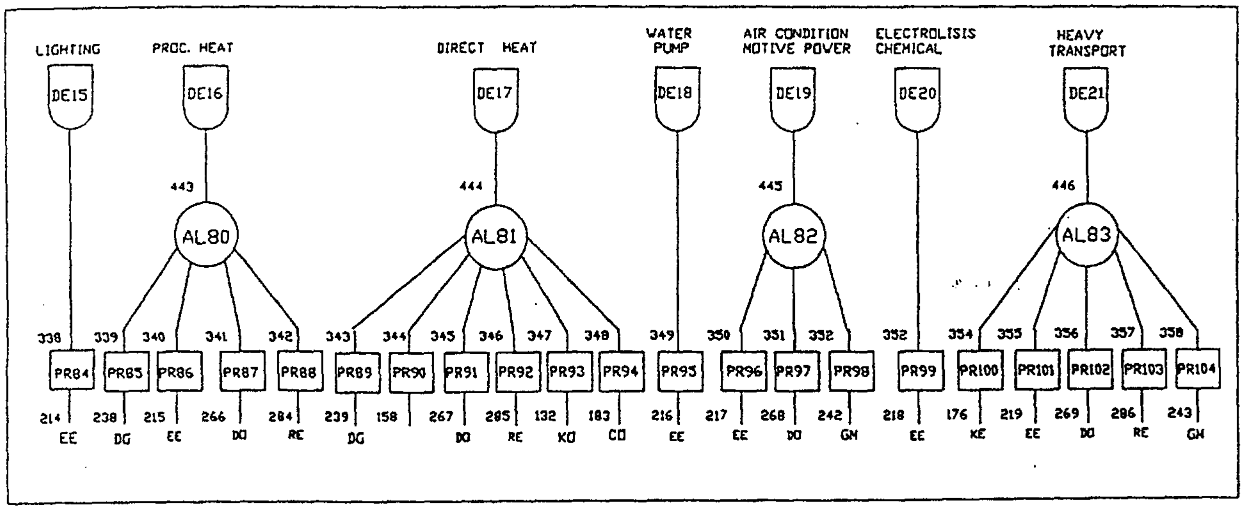


HEAT DIRECT INDUSTRIAL SECTOR

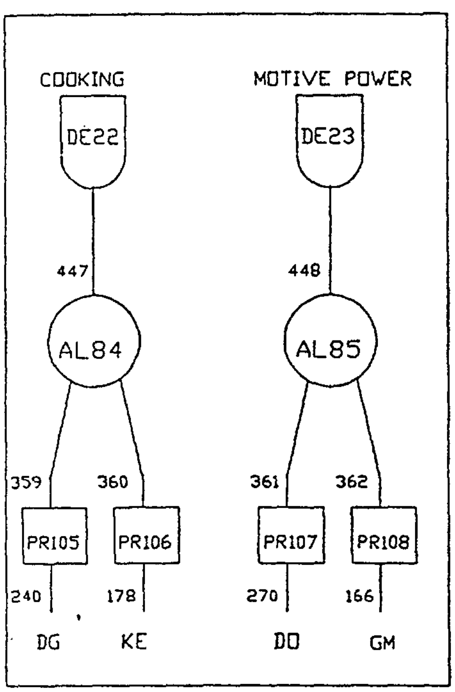


INDUSTRIAL SECTOR

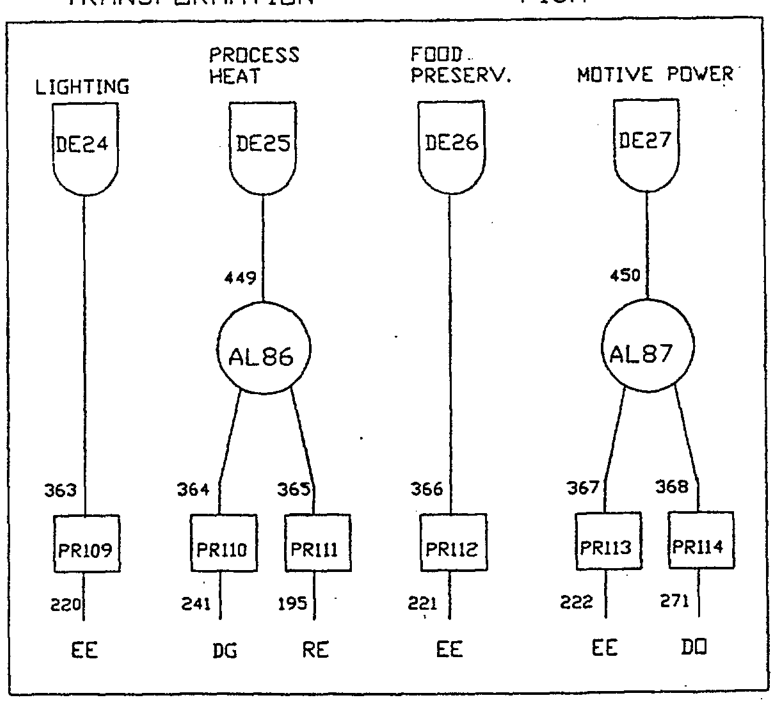
MINING

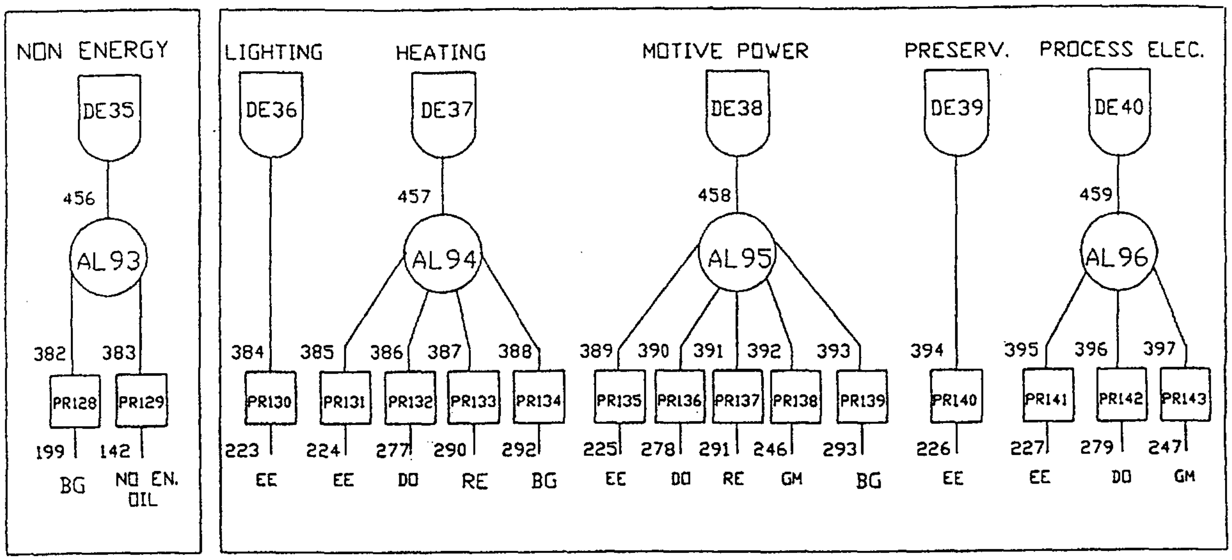


EXTRACTION FISH

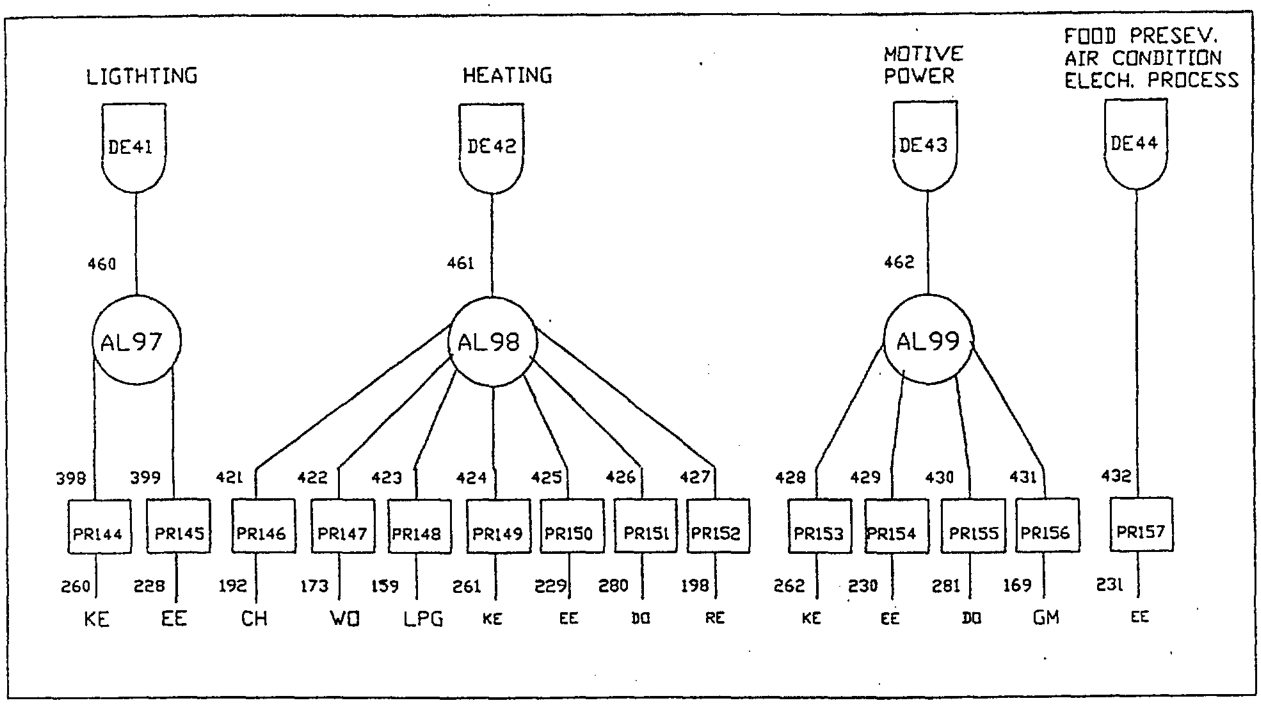


TRANSFORMATION FISH

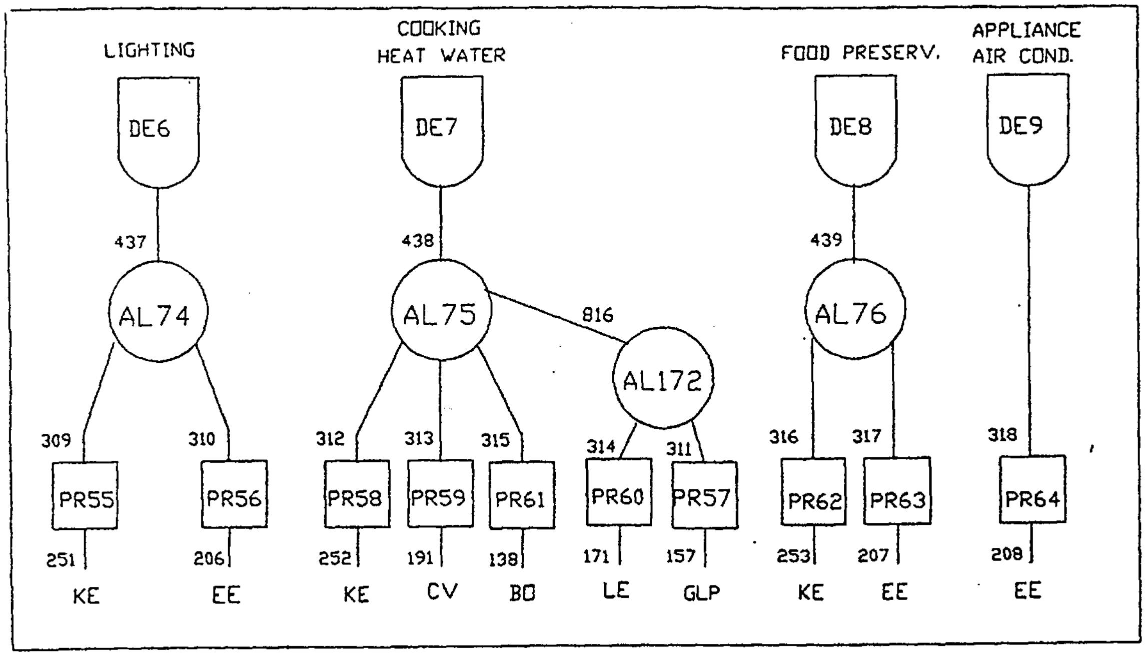




NON ENERGY AGRICULTURE AND CATTLE, AGRICULTURAL INDUSTRY SECTOR

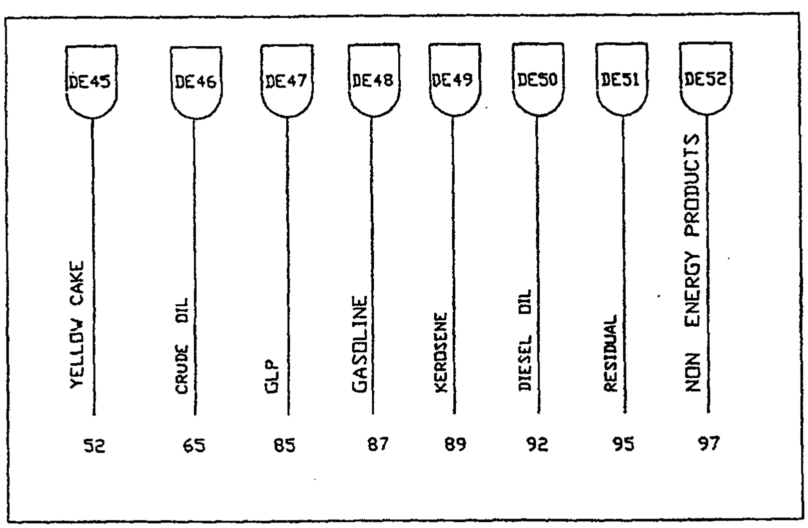


COMMERCIAL, SERVICES AND PUBLIC



RURAL SECTOR

EXPORT



B. APPENDIX B

B.1 Simbology used in the tables I.1.11 - I.1.17, and I.2.2 - I.2.5

1. Energy Products

BG	:	Bagasse
BO	:	Dung
CM	:	Coal
CQ	:	Coke
CV	:	Charcoal
DO	:	Diesel oil
EE	:	Electricity
GD	:	Distributed Gas
GI	:	Industrial Gas
GLP	:	Liquified Petroleum Gas
GM	:	Motor Gasoline
KE	:	Kerosene
LE	:	Wood
RE	:	Residual
TC	:	Jet Fuel

2. Units

KBOE	:	Thounsands of Barrels of Oil Equivalent.
MMT	:	Millions of Metric Tons.

B.2 Simbology used in the Energy Network

RS	:	Depletable Resource Process
RN	:	Renewable Resource Process
AL	:	Decision/Allocation Process
PR	:	Transformation Process (Transport)
RE1	:	Gas Refinery
RE2	:	Oil Refinery
ST	:	Stockpile
PP	:	Prices regulation process
DE	:	Demand Process
BG	:	Bagasse
BO	:	Dung
CM	:	Coal
CQ	:	Coke
CV	:	Charcoal
DO	:	Diesel oil
EE	:	Electricity
GD	:	Distributed Gas

GI	:	Industrial Gas
GLP	:	Liquefied Petroleum Gas
GM	:	Motor Gasoline
KE	:	Kerosene
LE	:	Wood
RE	:	Residual
TC	:	Jet Fuel
NE	:	Non Energy Products
N	:	Nuclear
H	:	Hydro
GN	:	Natural Gas
S	:	Solar
E	:	Eolic
SICN	:	Central North Intrconectal System
SISUR	:	South Interconectal System

LAND USE CHANGE AND FORESTRY AREA

			MODULE	LAND USE CHANGE AND FORESTRY										
			SUB MODUL	FOREST CLEARING - CO2 RELEASE FROM BURNING ABOVE GROUND BIOMASS ON AND OFF SITE										
			WORKSHEET	5-1										
			SHEET	A						B				
				PASO 1						PASO 2				
Forest Types				A Area Cleared Annually (Kha)	B Biomass Before Clearing (t dm/ha)	C Biomass After Clearing (t dm/ha)	D Net Change in Biomasss (t dm/ha)	E Annual Loss of Biomass (Kt dm)	F Fraction of Biomass Burned On Site	G Quantity of Biomass Burned On Site (Kt dm)	H Fraction of Biomass Oxidized On Site (Combustio Efficiency)	I Quantity of Biomass Oxidized On Site (Kt dm)	J Carbon Fraction of Aboveground Biomass (burned on site)	K Quantity of Carbon Released (Kt C)
							D=(B-C)	E=(AxD)		G=(ExF)		I=(GxH)		K=(IxJ)
Tropical	Closed Forests	Broadleaf	Undisturbed	270	275.2	10	265.2	71604	0.95	68023.80	0.9	61221.4	0.45	27549.6

Table C.7 CO2 emission due to clearing forestry

LAND USE CHANGE AND FORESTRY AREA

MODULE	LAND USE CHANGE AND FORESTRY		
SUB MODULE	FOREST CLEARING - CO2 RELEASE FROM BURNING ABOVE GROOUND BIOMASS ON AND OFF SITE		
WORKSHEET	5-1		
SHEET	C		

Forest types				STEP 3						STEP 4	
				L	M	N	O	P	Q	R	S
				Fraction of Biomass Burned Off Site	Quantity of Biomass Burned Off Site (Kt dm)	Fraction of Biomass Oxidized Off Site (Combustion Efficiency)	Quantity of Biomass Oxidized Off Site (Kt dm)	Carbon Fraction of Above-ground Biomass (burned off site)	Quantity of Carbon Released as CO2 (from biomass burned off site)	Total Carbon Released as CO2 (from on & off site burning)	Total CO2 released (Kt CO2)
					M=(ExL)		O=(MxN)		Q=(OxP)	R=(K+Q)	S=(Rx[44/12
Tropical	Closed Forests	Broadleaf	Undisturbed	0.03	2148.12	0.9	1933.308	0.45	869.99	28419.63	104205

Continuation of table C.7