# SUSTAINABILITY AND SUSTAINABLE DEVELOPMENT INDICATORS CASE STUDY: EGYPT'S ELECTRIC POWER SUPPLY SYSTEM

**Samia M. Rashad**
*Atomic Energy Authority*
*3 Ahmed El-Zomor St., El-Zohoor Dist, Nasr City, Cairo, Egypt*
*Samia_Rashad @ hotmail.com*

This paper addresses sustainability criteria and the associated indicators allowing operationalization of the sustainability concept in general and specially in the context of electricity supply. The criteria and indicators cover economic, environmental and social aspects.

Egypt has rapidly growing population and per capita demand. As a signatory of the framework convention on climate change, Egypt is making all efforts to comply with the strategy of Egypt to meet the challenge of the increasing demand management, integrating it into national decision making and improving environmental performance continuously: for the electricity sector, this can be summarized in improvement of power system efficiency by all available means. On the other hand energy conservation and demand side management programs are ongoing, also the environmental consideration has become one of the major issues in calculating the feasibility of any new addition to the system.

This paper deals with the review of the Macro Indicators based on total greenhouse emissions provide a measure of overall performance. Then propose the Primary Indicators. A set of performance indicators is developed against which implementation of the national strategy measures aimed at reducing green house gas emissions can be evaluated. Some selected results from environmental analysis are given. In the study about 20 indicators are used as a measure of the overall performance relative to targets and benchmarks for past and future projections up to year 2020. The potential performance indicators for energy sector include: fossil fuel consumption (primary energy), greenhouse gas emissions from energy sector, energy related greenhouse gas emissions per unit of energy delivered, energy related greenhouse gas emission per unit GDP, and energy related greenhouse gas emission per capita. The selected indicators are used to measure progress towards sustainable development in the country.

## 1- INTRODUCTION

Sustainable development of a society depends mainly on the availability of energy resources and how efficiently they are utilized. Secure reliable supply of electricity with minimum cost to different sectors of the Egyptian economy is one of the main concern of the Ministry of Electricity and Energy. To fulfil this target, a strategy has been set since the beginning of the eighties, focusing on: energy efficiency; institutional restructuring of the power sector; enhance the utilization of new and renewable energy sources; electrification of all the rural villages and attachments; localization of electrical equipment, and electric interconnection with neighbouring countries.

From the beginning of 1991, the Government of Egypt (GOE) has undertaken an Economic Reform and Structural Adjustment Program (ERSAP), which aimed at restoring financial balances and promoting economic growth through the development of a decentralized, market basis, outward – oriented economic system, where the private sector is expected to play more than a catalytic role.

This paper deals with how to choose a set of sustainable development indicators for the country. Development Indicators should be more than growth indicators. They should be about efficiency, sufficiency, equity, and quality of life. They must shift emphasis from money to physical units and from quantity of material throughput to quality of life. One of the first attempts to indicate actual human development rather than money flows is the human development index (HDI), it is a mathematical average of three indicators: average life expectancy, average educational attainment and GDP per capita. A review of a number of sets for indicators is given.

## 2- SUSTAINABLE DEVELOPMENT INDICATORS

### 2-1 Defining Sustainability

The most popular definition of sustainability can be traced to a 1987 UN conference. It defined sustainable developments as those that "meet present needs without compromising the ability of future generations to meet their needs" [1]. This well-established definition sets an ideal premise, but do not clarify specific human and environmental parameters for modelling and measuring sustainable developments. The following definitions are more specific:

A. "Sustainable means using methods, systems and materials that won't deplete resources or harm natural cycles" [1], [2]

B. Sustainability "identifies a concept and attitude in development that looks at a site's natural land, water, and energy resources as integral aspects of the development" [1].

C. "Sustainability integrates natural systems with human patterns and celebrates continuity, uniqueness and place making" [3].

In review of the plurality of these definitions, the site or the environmental context is an important variable to most working definitions of sustainability. This emphasis is expressed in the following composite definition:

Sustainable developments are those which fulfill present and future needs [1] while [only] using and not harming renewable resources and unique human-environmental systems of a site: air , water, land, energy, and human ecology and/or those of other [off-site] sustainable systems [2] , [3].

### 2-2 Convolution of Human and Natural Systems

In a systems view of sustainable development six essential subsystems can be distinguished. In order to define an indicator set for the assessment of societal development, we must first identify the different relevant sectors or subsystems of the societal system. We must include the systems that constitute society as well as the systems on which human society depends. A useful distinction of subsystems is the following [2]:

- *Individual development* (civil liberties and human rights, equity, individual autonomy and self-determination, health, right to work, social integration and participation, gender and class-specific role, material standard of living, qualification, specialization, adult education, family and life planning horizon, leisure and recreation, arts).

- *Social system* (population development, ethnic composition, income distribution and class structure, social groups and organizations, social security, medical care, old age provisions).
- *Government* (government and administration, public finances and taxes, political participation and democracy, conflict resolution (national, international), human rights policy, population and immigration policy, legal system, crime control, international assistance policy, technology policy).
- *Infrastructure* (settlements and cities, transportation and distribution, supply system (energy, water, food, goods, services), waste disposal, health services, communication and media, facilities for education and training, science, research and development).
- *Economic system* (production and consumption, money, commerce and trade, labour and employment, income, market, interregional trade).
- *Resources and environment* (natural environment, atmosphere and hydrosphere, natural resources, ecosystems, species, depletion of nonrenewable resources, regeneration of renewable resources, waste absorption, material recycling, pollution, degradation, carrying capacity). Other ways of subdividing the total system are possible.

The major relationships between the six subsystems are shown in Figure. 1. Each of these subsystems can be viewed as representing a certain type of potential that is vital to the development of the total system.

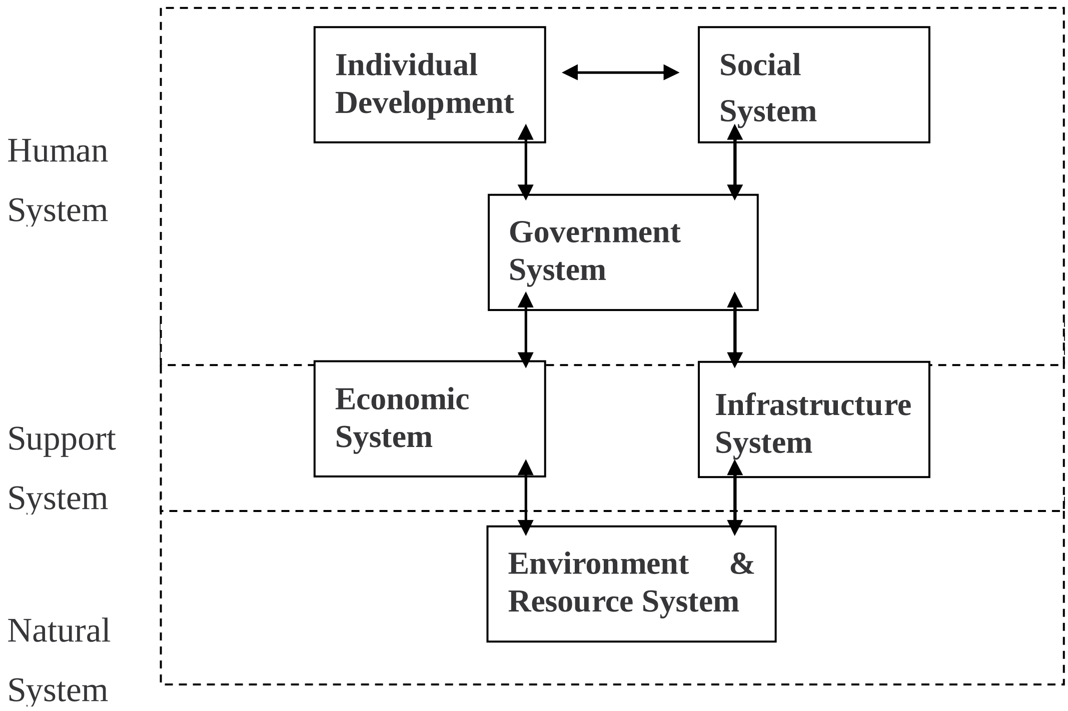


**Figure 1**. The six major systems of the anthroposphere and their major relationships. These six sector systems can be aggregated to the three subsystems: human system, support system and natural system

The six subsystems can be aggregated to three subsystems: human system, support system, natural system, for each subsystem there is a need to a number of indicators to capture all aspects of its viability and sustainability and of their contributions to viability and sustainability of the total system. The total number of indicators increases with the number of subsystems we include. To keep the number of indicators at manageable level, we can aggregate the six sector systems to three subsystems:

- human system = social system + individual development + government

- support system = infrastructure + economic system
- natural system = resources + environment

**2-3 Changing Character of Environmental Problems**

It is well-known that the character of the environmental problems has changed. The following are four important changes (Figure 2.)[2,4]:

*(i) Local to global*: Many of the local pollution problems around industries have been solved by building higher chimneys and longer discharge pipes. But this "philosophy of dilution" only transferred local problems, with some delay, into regional problem. The scope of environmental issues has proceeded to an even greater geographical scale, and today the global environmental issues often dominated the environmental discussion. In Sweden, and in many other countries, the emissions of sulphur dioxide and nitrogen oxides that cause regional acidification have been reduced, but the emissions of $CO_2$, causing global greenhouse effect, are still left to be dealt with.

*(ii) Specific to diffuse*: In the fifties the activities that caused the environmental problems often were distinguishable specific sources, like factory chimneys and discharge pipes etc. Substances that earlier went out through these chimneys and pipes, are today often collected in filter devices. These filters cause diffuse discharges when they are deposited. Furthermore, today the diffuse emissions from the consumption sector dominate over the specific emissions from the production sector for many substances.

*(iii) Short delay to long delay*: The fact that many substances are embedded in filters etc, from the production processes as well as in products, also imply that there is a longer delay before we can recognize a damage in nature. For substances that are captured in a filter from a purifying plant it can take several hundred years from the time the filter is deposited until the substances reach the ground water. This means that, for many substances, the annual emission only constitutes a small amount of the large accumulation within the technosphere and in waste deposits.

*(iv) Low Complexity to high complexity*: The causal chains of the environmental problems have become more complex. Today, many different activities cause many different environmental problems in many different ways. The historical societal influence on nature was often characterized by quite simple chains, e.g., a dead lake poisoned by a nearby factory. Today the causal chains in the societal influence on nature look more like a brushy web.

The changing character of the environmental problems, described above, implies that we can not use our senses to detect if society's influence on nature is sustainable or not. We need to apply a systems perspective to sort out the most relevant information on society's physical influence on nature.

Figure 3. shows the increasing use of non-renewable energy. The fact that resources from the lithosphere are finite, clearly indicates that this use is unsustainable, but for most of these resources, the assimilation capacity is even more restrictive

Figure 4. illustrated the increasing production of formulated pesticide, which can be seen as one of many indicators for the increasing production of chemicals that are foregin to nature. The number of chemicals used in the society has virtually exploded. In the present industrial society, tens of thousands of chemicals are used regularly. There are, for example, over 70000 chemicals in the U.S. TSCA (Toxic Substances Control Act Inventory)[5] . Around 11000 organochlorines have been identified, of which very few occur naturally; most are produced and released by society. The production of chlorine, that has increased by a factor of 10 in thirty years, can be regarded as an indicator of production of these kinds of substances [6].

Figure 5. shows the increasing manipulation of land areas of the world. This trend is ultimately limited by the available exploitable land area of the Earth (the dashed line).

Furthermore, the crop production, which is essential to feed a growing world population, is even more constrained: 78% of the total land area is ice-covered or too cold, too dry, too steep, too shallow, too wet or too poor to permit crop production and of the remaining 22%, 13% (of the total) is weakly productive, 6% moderately productive and only 3% highly productive [7].

The manipulation of the sea areas of the world has also increased. The world fish catch has increased 4.5 times since 1950 and all 17 major fishing areas in the world have either reached or exceeded their natural limits [8].

Figure 6. illustrates another unsustainable trend, the growth of the world population According to the United Nations conferences on population policies.

## 3- PRINCIPLES FOR SUSTAINABILITY

Indicators for sustainability can be divided into three (main groups: (i) societal activity indicators (that indicate activities occurring within the society: the use of extracted minerals, the production of toxic chemicals, recycling of materials (ii) environmental pressure indicators (that indicate human activities that will directly influence the state of the environmental e.g., emission rates of toxic substances) and (iii) indicators of the state of the environment or environmental quality indicators (that indicate the state of the environment, e.g., the concentration of heavy metals in soils and pH-levels in lakes).

In some studies formulation of indicators for sustainability based on a framework of principles that should be fulfilled in a sustainable society. In this framework, four critical aspects of industrial society are identified. Three of them deals with the societal interaction with nature characterized by (1) the use and emissions of lithospheric materials, (2) the use and emissions of substances produced in society, and (3) anthropogenic manipulation of nature that affects the long term productivity of the ecosystems. The fourth aspect deals with efficiency and equity in the context of societal resource use.

For each of these critical aspects a principle is formulate [3,9,10,11].

Principle 1: Substances extracted from the lithosphere must not systematically accumulate in the ecosphere.

Principle 2: Society produced substances must not systematically accumulate in the ecosphere.

Principle 3: The physical conditions for production and diversity within the ecosphere must not systematically be deteriorated.

Principle 4: The use of resources must be efficient and just with respect to meeting human needs.

Indicators:

Principle 1:

Indicator no. 1.1 : Lithospheric extraction rates.

Indicator no. 1.2 : Accumulated lithospheric extraction

Indicator no. 1.3 : Non renewable energy supply

Principle 2:

Indicator no. 2.1 : anthroppgenic flows compared to natural flows

Indicator no. 2.2 : The long term implications of the present emissions

Indicator no. 2.3 : Production volumes of persistent chemicals foreign to nature.

| | |
|---|---|
| Indicator no. 2.4 : | Societal knowledge of the global production of persistent substances. |
| Indicator no. 2.5 : | Long term implication of emissions to the atmosphere |

Principle 3:

| | |
|---|---|
| Indicator no. 3.1 : | Transformation of lands |
| Indicator no. 3.2 : | Soil Cover |
| Indicator no. 3.3 : | Nutrient balance in soils |
| Indicator no. 2.4 : | Harvesting of funds |
| Indicator no. 2.5 : | Freshwater supply |

Principle 4:

| | |
|---|---|
| Indicator no. 4.1 : | Overall efficiency |
| Indicator no. 4.2 : | Supply |
| Indicator no. 4.3 : | Justice |
| Indicator no. 4.4 : | Basic human needs |

## 4- PERFORMANCE INDICATORS

The idea of an indicator is to minimise the number of measurements needed to characterise an outcome. We are therefore proposing a further classification of indicators at the macro and sectoral levels, namely, primary and secondary indicators. The primary indicators together provide an overall assessment of performance based on a small number of measurements, while the secondary indicators allow a better understanding of the reasons underlying changes in the primary indicators.

### 4-1 Macro Indicators

Macro indicators based on total greenhouse emissions provide a measure of overall performance. Changes in levels of green-house gases over time are an expression of the policies and measures adopted by a country and hence trends in total emissions can be used as the basis for comparison with other countries, to compare past and projected levels and to identify performance relative to targets and benchmarks.

At the macro level, it is suggested that economic activity and population are the major pressures influencing greenhouse gas emissions. Because of the strong connections between individual and community activities and emissions, population can be a major determinant in the level of emissions and consequently, changes in the level of emissions per head of population is of interest as this measurement is commonly used for inter-country comparisons. These various measurements are:

1- Total Emissions – Trends with time.
2- Emissions per unit of economic activity.
3- Emission per capita.
4- Emissions, GDP and population.
5- Emissions per unit of land area.
6- Emissions and Exported Goods.

### 4-2 Primary and Secondary Indicators

In choosing primary indicators, we have selected those measurements that best encapsulate most or all of the outcomes needed to achieve the objectives and strategies. The secondary indicators have been selected on the basis that they can assist in explaining most of the underlying reason for change in primary indicators. Table 1. gives proposed primary indicators for all sectors including energy sector

**Table 1.** Proposed Primary Indicators

| | |
|---|---|
| Macro Indicators | Total Emissions ($CO_2$ Equivalents)<br>Total Emissions per Unit of GDP<br>Total Emissions per Capita |
| Sectoral Indicators<br>All Sectors | Total Emissions from each sector |
| Energy | Energy Emissions per Unit of GDP<br>Energy Emissions per Capita |
| *Energy Supply* | Emissions from Energy Delivered by Fuel Type |
| *Household Energy* | Emissions for Household Energy per Capita |
| *Industrial and Commercial Energy* | Emissions per Unit of Energy Delivered |
| *Transport* | Emissions per km Travelled by Mode |
| *Transport and Urban Planning* | Emissions per km Travelled in Urban Areas by Mode |
| *Industry Process Emissions* | Emissions from the Cement Industry |
| Agriculture | $N_2O$ Emissions Index |
| Natural Environment | $CO_2$ from Landuse Change |
| Waste | Carbon dioxide and<br>Methane Emissions per Capita |
| Diagnostic Indicators | A number of diagnostic indicators are also considered |

Energy use is associated with a wide variety of activities. Table 2 shows the potential indicators for Energy Sector.

**Table 2**. Potential Indicators for Energy Sector

| Outcome | Potential Performance Indicators |
|---|---|
| • Reduce greenhouse gas emissions through improved efficiency of supply and use Switch to lower greenhouse impact fuels where cost-effective. | • Fossil fuel consumption (primary energy)<br>• Greenhouse gas emissions from energy sector<br>• Energy-related greenhouse gas emissions per unit of energy delivered<br>• Energy-related greenhouse gas emissions per unit GDP<br>• Energy-related greenhouse gas emissions per capita |

### 4-3 Energy Supply

Energy conversion and supply losses are responsible for around 40% of total energy-related greenhouse gas emissions. Table 3. outlines summary of energy supply sector outcomes.

**Table 3.** Summary of Energy Supply Sector Outcomes, Primary and Secondary Indicators

| Summary of Outcomes | Primary Indicators | Secondary Indicators |
|---|---|---|
| Reduced energy use<br><br>More efficient energy use<br><br>More efficient energy production and distribution<br><br>More energy from lower reenhouse gas emitting sources | • Greenhouse gas emissions from energy delivered by fuel type | • Greenhouse gas emissions from energy delivered per unit of economic activity |

## 5- EGYPT'S CASE STUDY

Egypt has at present a population of 72 million, which is expected to increase rapidly at a rate of 2.1% per annum. This gives rise to an ever-increasing demand for energy resources to achieve social and economic development goals of the country. Table 4 gives the main technical features of the Egyptian electric power systems during year 2002/2003[12]. From 1978 natural gas is becoming an attractive source of energy in Egypt, both reduce to dependence on oil and from the environmental point of view. About 15% of the total energy generated in Egypt is hydro energy. This allows avoidance of about 2 million tones of $CO_2$ in 1967 and avoidance of between 8 to 10 million tones of $CO_2$ yearly in the last 15 years. $CO_2$ emissions from fossil fuels in the electricity sector are about one fourth of the total $CO_2$ emission in the country. Comparing the picture of energy and $CO_2$ emission factors for some countries in 1998, the values for the energy /capita(GJ) the value of $CO_2$ / energy (kg $CO_2$ /GJ) the value of $CO_2$ in $tCO_2$ /capita for Egypt and China are as follows : 25.3, 59.5, 1.5 for Egypt and 22.3, 76.5,1.71 for China, respectively. The peak load, the total electric energy consumed and the total installed capacity have been increased from 10919 MW, 44 TWh, 13870 MW in 1997 /1998 to 14401 MW, 87 TWh, 17671 MW in 2002/2003, respectively.

The pattern of electricity consumption shows that: industrial sector (50%), residential and commercial sectors (35%), governmental and services (tertiary) sectors (10%) and agriculture and land reclamation (5%). Generation Efficiency improvement has been achieved through major policy actions: improving supply side efficiency, minimizing transmission and distribution losses and introducing demand side management [11,13] .The rate of fuel consumption has been decreased from 334 gm/kWh in 1982 to 224 in 1996 and 221 in 2002 with the total efficiency increase from30% in 1982 to 43% in 1996 and 2002.

The assessment of energy resources, production, conversion, transportation and consumption are the major basic tool for formulating and evaluating the structure of energy sector and its interaction with other sectors of the economy. Table 5. shows the percentage of primary energy consumption and carbon dioxide emissions by sector. Figure 7. illustrates the evolution of peak load, Electric energy and per capita electricity consumption over the years 1980-2020.

**Table 4.** Main Technical Features of the Egyptian Electric Power System In Year (2002/2003)

| | 1995 | 1996 | 2002/2003 |
|---|---|---|---|
| Max Load MW | | | 14401 |
| Total energy generated MkWh | | | 89190 |
| Hydro MkWh | | | 12859 |
| Thermal MkWh | | | 68204 |
| Sharing from wind, BOOT, industrial companies | | | 8127 |
| Installed capacity MW | | | 17671 |
| Hydro | | | 2745 |
| Thermal | | | 13498 |
| Wind | | | 63 |
| Private sector thermal | | | 1365 |
| Fuel consumption (equiv.) 1000 ton | | | 15224 |
| Mazout | | | 1642 |
| Natural gas (NG) | | | 13579 |
| Solar | | | 3.3 |
| Gas consumed by private sector (BOOT), million $m^3$ | | | 1829 |
| Thermal efficiency | | | 39.2 % |
| Fuel consumption rate gm/kWh generated | | | 223.5 |
| Percentage of NG/total fuel consumed | | | 89.2 % |
| Transmission Line Lengths (km) | | | |
| 500 kV | | | 2277 |
| 400 kV | | | 33 |
| 220 kV | | | 13803 |
| 132 kV | | | 2549 |
| 66 kV | | | 14855 |
| 33 kV | | | 2526 |
| Substation Capacity (MVA) | | | |
| 500 kV | | | 10155 |
| 220 kV | | | 24605 |
| 132 kV | | | 3591 |
| 66 kV | | | 27917 |
| 33 kV | | | 1851 |

**Table 5.** Consumption of primary energy, electricity and carbon dioxide emissions in Egypt (% of the total) for the main sectors [13].

| **Consumption of Petroleum Products (by sector)** | |
|---|---|
| Transportation | 36.6% |
| Industry | 30.5% |
| Residential and Commercial | 15% |
| Power System | 14% |
| Petroleum Sector | 3.4% |
| Agriculture | 0.5% |

| **Continued Table 5** | |
|---|---|
| **Consumption of NG (by sector)** | |
| Industry | 16.7% |
| Petroleum | 8.9% |
| Power System | 73% |
| Residential | 1.7% |
| **Consumptions of Electricity (by sector)** | |
| Industry | 43.35% |
| Agriculture | 4.1% |
| Residential & Commercial | 37.8% |
| Governmental & Facilities | 14.75% |
| **Carbon Dioxide Emissions (by sector)** | |
| 83 Million Ton $CO_2$/a | |
| Electric Power System* | 30.4% |
| Industries (Light + Heavy) | 28% |
| Transportation Sector | 26% |
| Residential and Commercial | 10.2% |
| Petroleum Sector | 5% |
| Agriculture Sector | 0.4% |

* Not including hydro-power

## 6- RESULTS & DISCUSSION

The main objective of the study is to develop a set of performance indicators against which implementation of the national strategy measures aimed at reducing greenhouse gas emissions can be evaluated. A hierarchy of indicators macro, sectoral/ Sub-Sectoral and diagnostic indicators are proposed. At the macro level, economic activity and population are major pressures influencing greenhouse gas emissions. For finding indicators of sustainable development, the number of indicators should be as small as possible, but not smaller than necessary, that is the indicator set must be comprehensive and compact covering all relevant aspects. Given below some key performance indicators for Egypt, they include:

- Energy Demand (PJ), Real GDP of Egypt (US$),
- Population Growth Rate (Millions), Energy / Capita (GJ),
- REAL GDP / Capita (US$), % Renewable energy Sources / Total,
- Oil Reserves (Billion Barrels) and Natural Gas Reserves (Trillion Cu.Ft), Electricity consumption / capita (KWh/ Capita),
- Annual Primary Energy Intensity (TOE/1000 L.E.),Annual Electricity Intensity (kWh/ 1000 L.E.)
- Rate of fuel consumption of the Egyptian Thermal Generating units.
- Thermal efficiency of Egyptian Generating units,
- Index of power system $SO_2$ Emissions per Electricity Generated (1997=100).
- Index of Power system NOX emissions per Electricity Generated (1997=100).
- Index of Power system $CO_2$ Emissions per Electricity Generated (1997=100) ,
- Index of Power System NOX emissions per Electricity Generated (1997=100), and

- Oil & Gas Production as Compared with Total Energy Consumption.

Figures 7-12 illustrates the above mentioned indicators for the energy and electricity sectors in Egypt augmented performance Appendix1 is a list of augmented performance indicators.

## 7- CONCLUSION

The main objective of this work is to develop a set of performane indicators against which implementation of national strategy measures aimed at reducing greenhouse gas emission can be evaluated. Through this paper key performance indicators for Egypt are defined. some of these indicators are calculated.

## APPENDIX I

**Set of Measures and Indicators:**

- ♦ Annual Primary Energy Consumption GJ (TOE).
- ♦ Annual Electricity Consumption GWh.
- ♦ Annual Energy Intensity TOE / 1000 LE
- ♦ Annual Electricity Intensity kWh/ 1000 LE.
- ♦ Annual Primary Energy Consumption / Capita (TOE/ Capita).
- ♦ Annual Electrical Energy Consumption / Capita (kWh/ Capita).
- ♦ Energy Resource Utilization (Total Energy Consumption per Unit of Electricity Generation (GJ/ GWh).
- ♦ Fossil Fuel use (Fossil Fuel Consumption per Unit of Electricity Generation (GJ/ GWh).
- ♦ GDP (Gross Dometic Product) per Capita.
- ♦ Real GDP Per Capita Growth Rate.
- ♦ Import Dependence (Share of Imported fuel in Primary Energy Demand for Electricity Sector %).
- ♦ Investment Share in GDP %.
- ♦ Life Time of Proven Energy Reserves (Years).
- ♦ Depletion of Resources (% of Proven Reserves).
- ♦ Share of Renewable Resources (Ratio of Renewable Energy Sources to non-Renewable Energy Used).
- ♦ Depletion of Mineral Resources (% of Proven Reserves).
- ♦ Share of Manufacturing Value Added in GDP%.
- ♦ Export Concentration Ratio %.
- ♦ Incremental Land Use (ha).
- ♦ Crop Damage (S) Resulting From Ground Level Ozone;
- ♦ Damage to Exterior of Buildings (S) Due to Acid Gas and Particulate Matter.
- ♦ Acidic Deposition (mg/ Sq.m.).

- ♦ Power System Emissions of Sulphur Dioxide (Index of $SO_2$ Emissions Per Electricity Generated).
- ♦ Power System Emissions of Nitrogen Oxides. (Index of $NO_x$ Emissions Per Electricity Generated).
- ♦ Power System Emissions of GHG.
- ♦ $CO_2$/ Primary Energy (Kg $CO_2$/ GJ).
- ♦ $CO_2$ Emissions / GDP.
- ♦ $CO_2$ Emissions/ Capita.
- ♦ Tons of Solid Waste Produced.
- ♦ Amount of Material Recycled Per Person as a Ratio of Total Solid Waste Generated.
- ♦ Generation of Low & Intermediate Short Lived Radioactive Waste ($m^3$).
- ♦ Imports and Exports of Radioactive Wastes: (Kg or $m^3$) Total Amounts of Radioactive Wastes Subject to Transboundary Movements, Including a Breakdown of Specific Types.
- ♦ Area of land Committed Owing to the Presence of Radioactive Substances ($Km^2$).
- ♦ Generation of Radioactive Waste Owing to Naturally Occurring Radioactive Materials (NORM), Resulting From a Variety of Activities Unrelated to the Nuclear Industry ($m^3$).
- ♦ Operational Status of the Radioactive Waste Management System Processing Capacity $m^3$/ Annum, Storage Capacity $m^3$ of Used and/or Still Available Space, Disposal Capacity $m^3$ of Used, and or Still Available Space.

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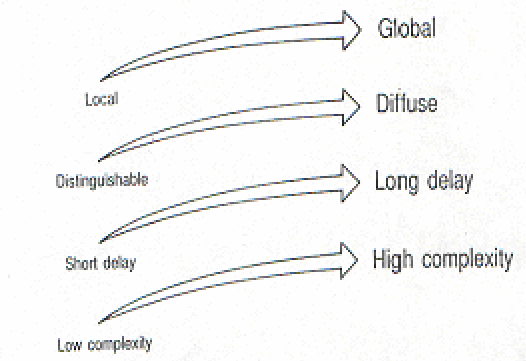



*Figure 2 : The changing character of the environmental problems.*

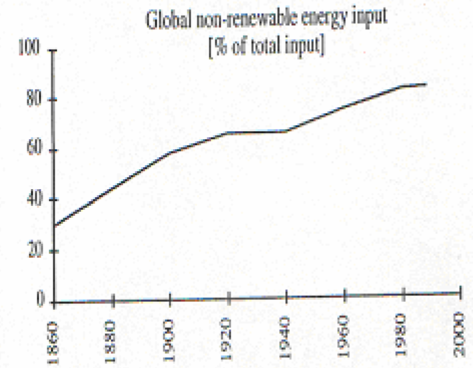



**Figure 3 :** The world use of non-renewable energy.

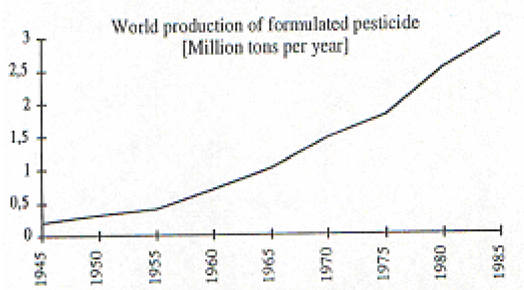



**Figure 4 :** The world production of formulated pesticide [Brown et al. 1994].

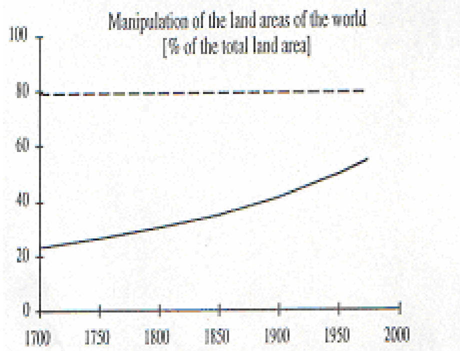



**Figure 5 :** The manipulation (exploitation, agriculture, forestry etc.) of the land areas

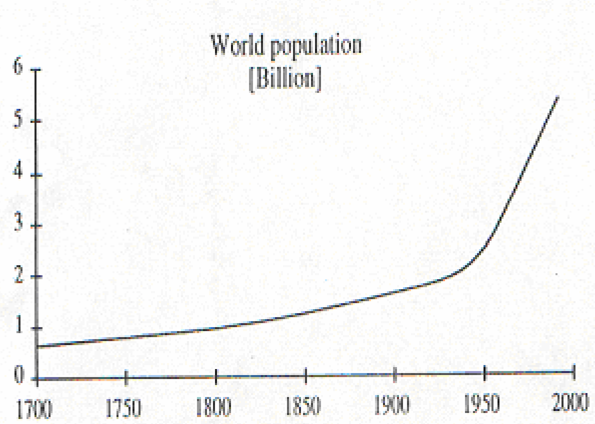



**Figure 6 :** The human population growth.

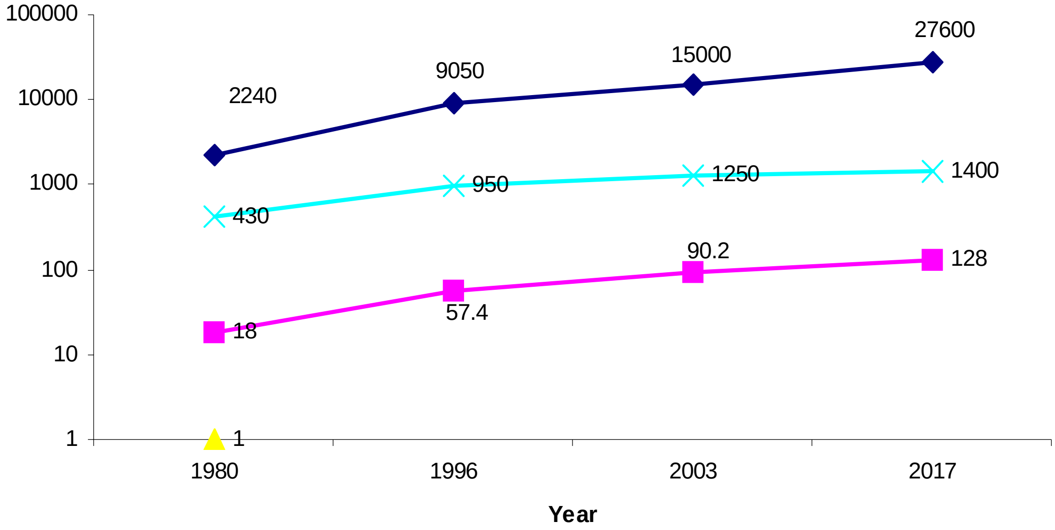
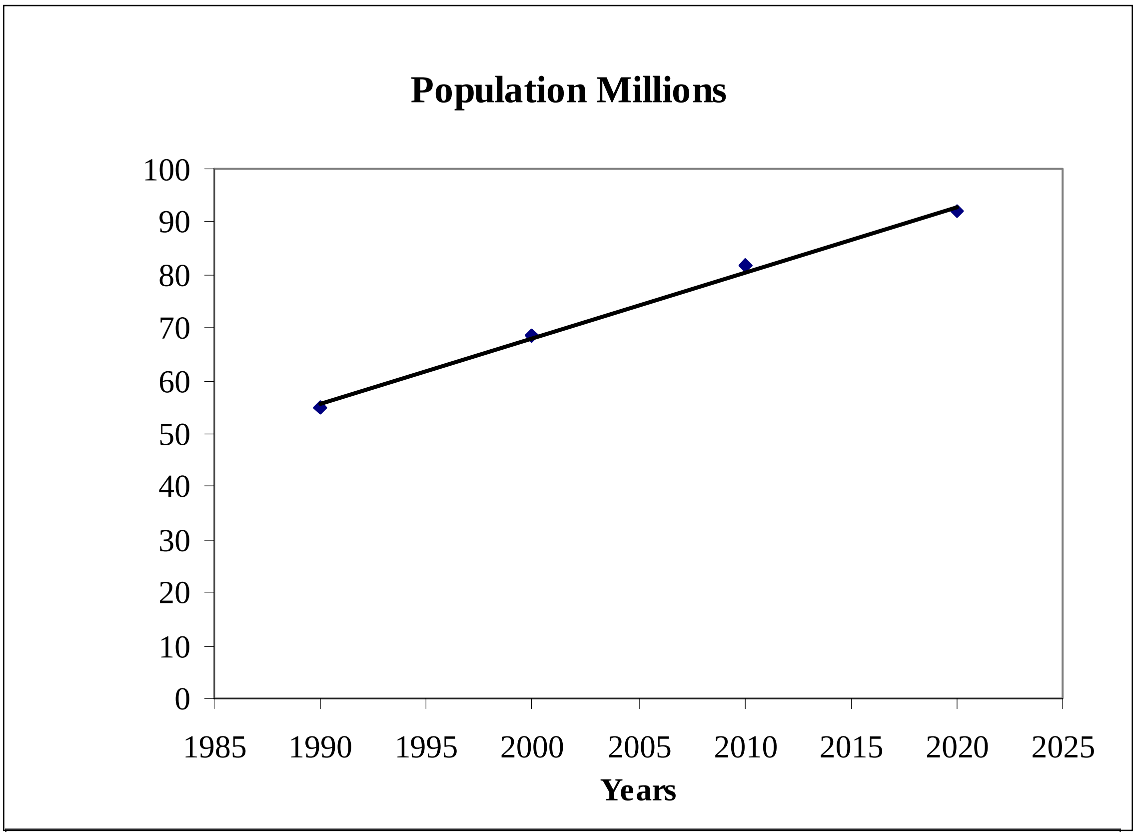



**Figure 7 Evolution of Peak load, Electric Energy. Percapita Electric Energy Consumption, 1980-2020.**



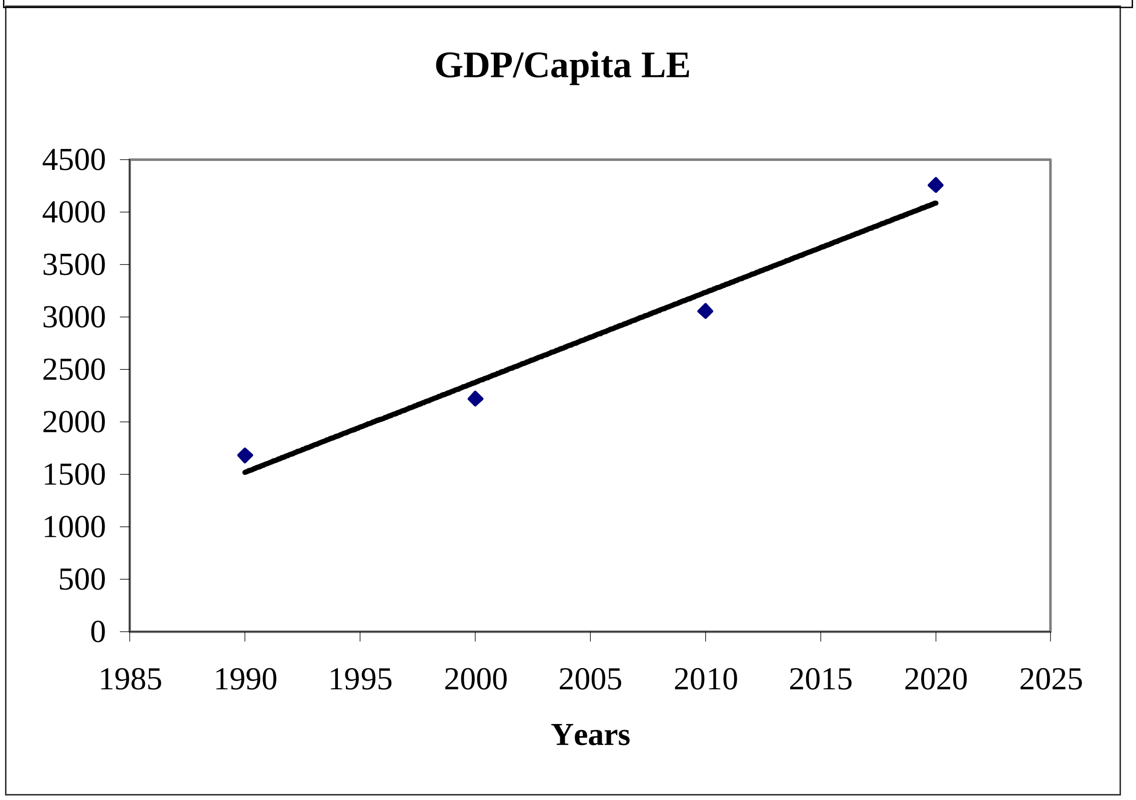




**Figure 8.** Population Millions and Real GDP/Capita LE Growth Rates of Egypt (1990-2020)

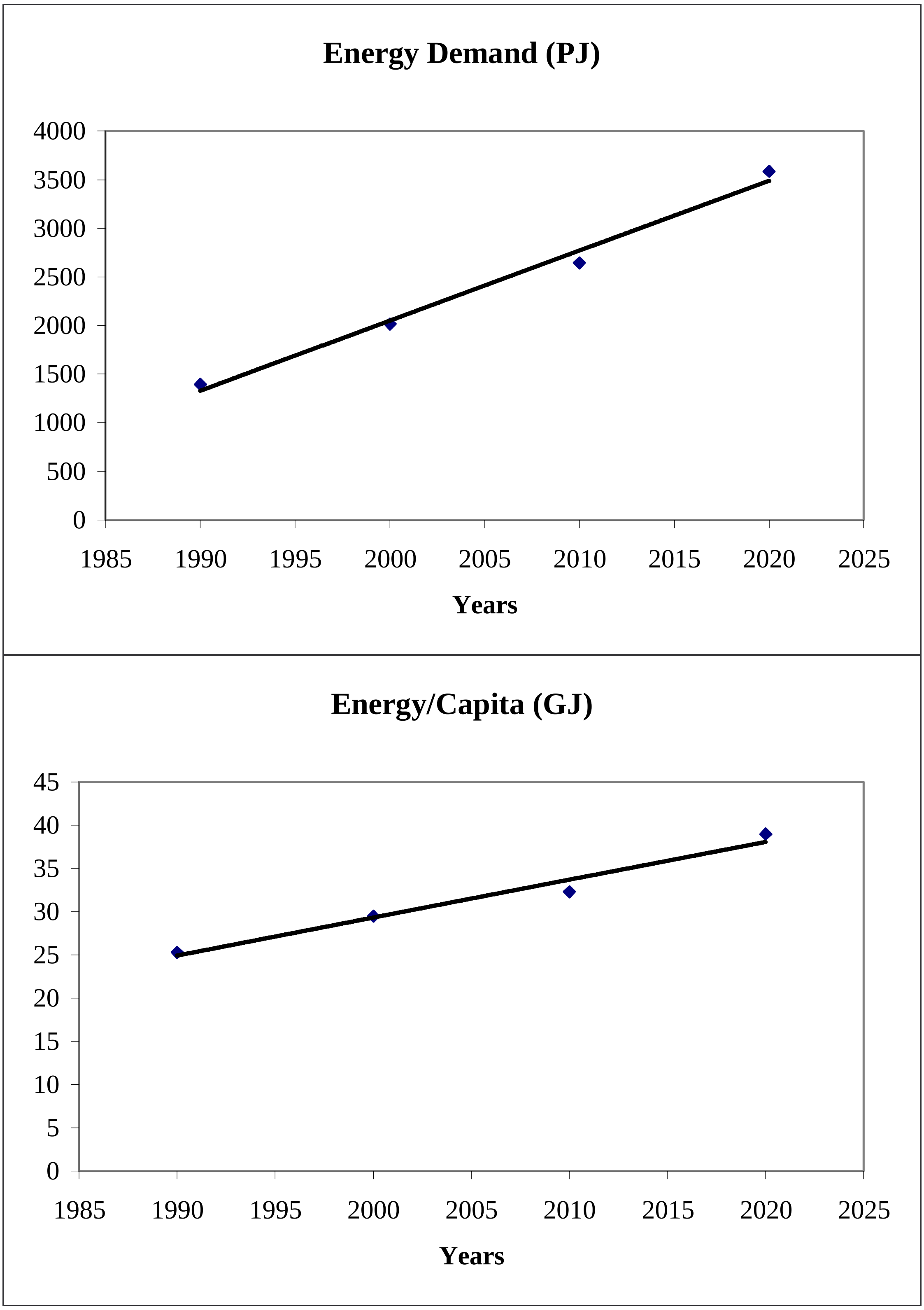



**Figure 9.** Energy Demand and Energy/Capita GJ Growth Rates of Egypt (1990-2020)

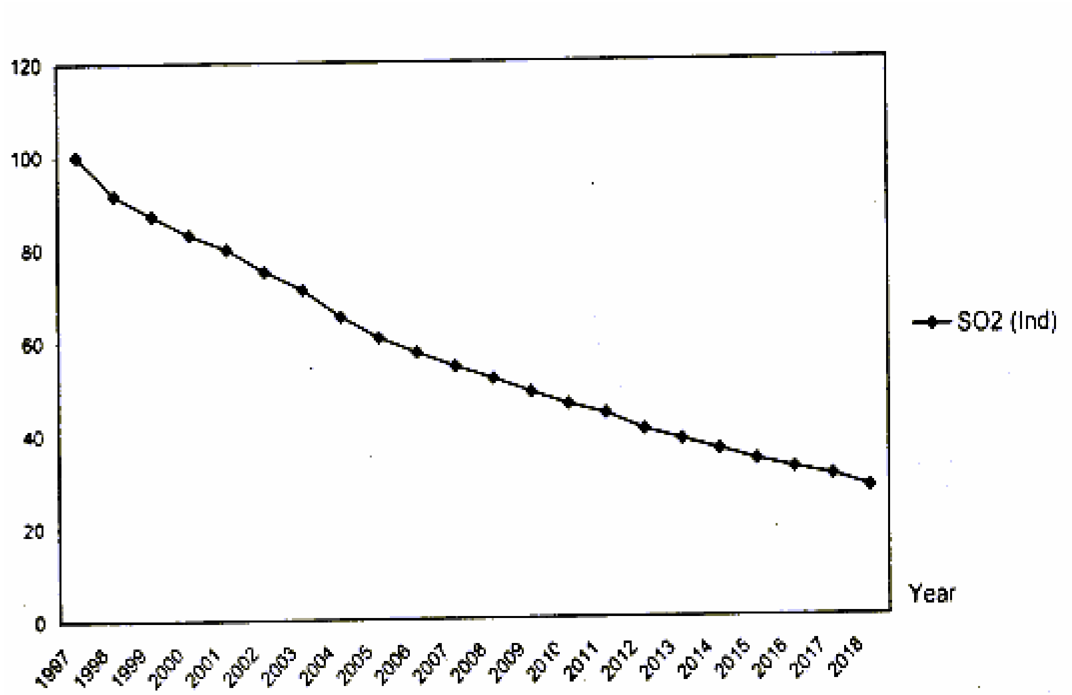



**Figure 10.** Index of power system $SO_2$ Emissions per Electricity Generated (1997=100)

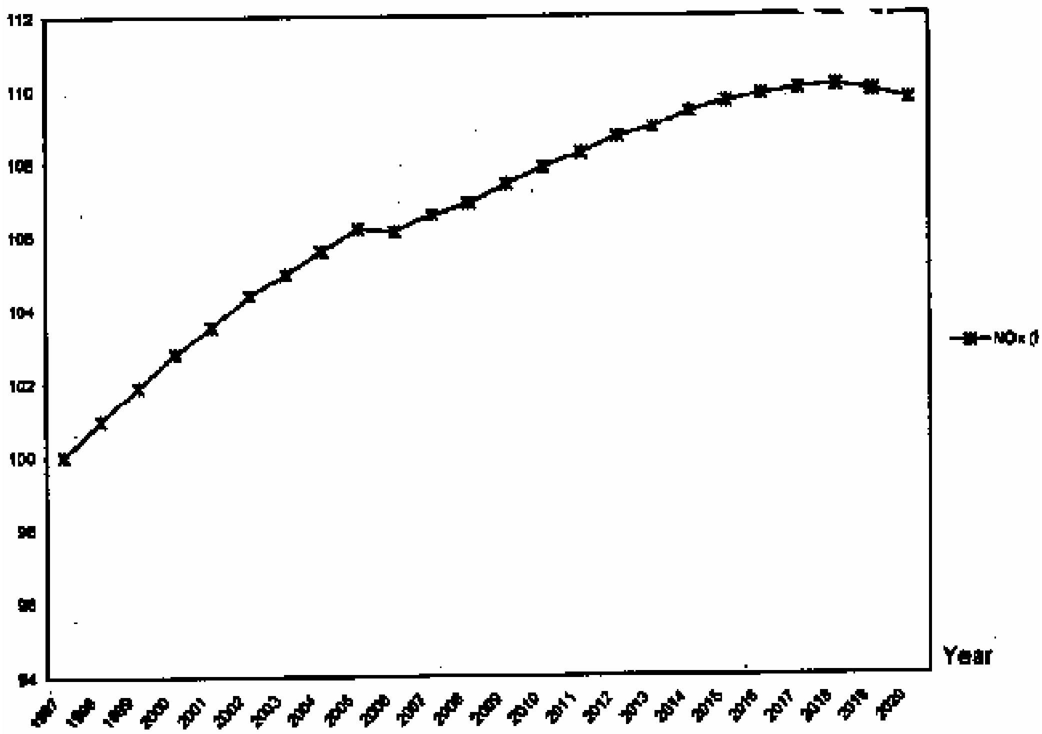



**Figure 11.** Index of power system Nox Emissions per Electricity Generated (1997=100)