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SUSTAINABLE DEVELOPMENT AND ENERGY SHORTAGE : THE CASE OF SUDAN (1980 - 1996)

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SUSTAINABLE DEVELOPMENT AND ENERGY SHORTAGE: THE CASE OF SUDAN

(1980 - 1996)

By
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Dedication

To my Dear Lovely parents... gift without complain or restriction with my ever lasting love and gratitude.

To my dear brothers and sisters... to whom I am really heavily indebted with my grateful thanks and love.

To Mohamed, Tahir, Rowan, Riyan and their parents with my grateful appreciation and love.

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Abstract

Energy is considered the driving force of all human activities since it is an indispensable input in the key productive sectors which provide many individual and collective needs.

In the context of sustainable development strategy, energy issues are critical partially because economic development has been linked to growth in energy supply consumption, and also because the environmental impacts of energy use are serious and hard to manage.

In the Sudan, during the last few decades, energy shortage in the productive sectors of the economy has significantly contributed to Sudan's present economic crisis and resulted in poor economic performance. Moreover, the pattern and structure of energy demand (consumption) in Sudan, inflicted a considerable environmental damage.

The methodological approach of the present study is descriptive, analytical and empirical in nature. The statistical and mathematical analysis is based on (1) the ordinary least squares technique and the double logarithmic demand function to estimate energy demand function, price and income elasticities at both Macro (aggregate) and Micro (sectoral) levels. (2) Simultaneous equation techniques to examine the importance of endogenous price assumption in the determination of oil import demand model, the two-stage least squares technique is used to verify the assumption that the demand for oil imports in the Sudan during the study period is significantly constrained by the availability of foreign exchange receipts. The study used the relevant computer application programmes (e.g. SPSS for windows programmes).

The study focused on the demand side because the nature of energy problem in the Sudan is significantly attributed to excess demand problems. Moreover, the study focused on macro and micro statistical

analysis of energy demand functions in the Sudan using sectoral and aggregate energy demand functions. The estimated equation at both sectoral (Micro) and aggregate (Macro) levels revealed inelastic demand function with respect to prices, and thus demand is insensitive to prices changes and therefore pricing policies are ineffective in managing energy demand particularly household demand for biomass, transport sector demand for gasoil and benzine. Most estimated equations are statistically significant and in most cases, the estimated parameters have the correct sign and therefore most estimated equations are consistent with the theoretical predications of the down-ward sloping demand curve, (except household demand for biomass, transport sector demand for gasoil and benzine, which have upward sloping demand curve due to price distortion during the study period). In most estimated equations income elasticity is less than unity and therefore energy is necessary good or commodity for the consuming sectors in the economy. In most estimated equations demand is insensitive to both incomes and prices changes and the income effect outweigh the price effect.

The present study verified the assumption that demand for oil imports in the Sudan is significantly determined or constrained by the availability of foreign exchange receipts.

Moreover, the present study revealed that per-capita total and commercial energy consumption in Sudan are very low compared with the other developing countries. However, during most of the study period, there was a considerable growth or increase in commercial per-capita energy consumption but slight growth or increase in total energy per-capita consumption.

On the other hand, the study revealed that although the energy sector in Sudan (on average) absorbed about 15.44% of total development expenditures during the period (1981-1994), the contribution of the energy sector in GDP was very weak and marginal and did not exceed 2.5% during the period (1980-1990), the contribution of electricity and water sector in GDP during the same period was ranged between 1% and 2.3%. The annual consumption growth rate of electricity sector outweigh the annual consumption growth rate of biomass, oil and even total energy sector during the period (1981-1989).

Finally the study revealed that, the high dependence on oil as a major commercial energy source has serious implications for the performance of the economy. Moreover, oil imports have significantly contributed in raising the rate of inflation, through their direct impacts on general prices and costs of domestic or locally produced commodities that depend on oil imports.

Based on the results obtained the following recommendations are made: (1) Implementation of an integral or a comprehensive energy strategy at sectoral, regional and national levels. (2) Adjustment of pricing system. (3) Enhancement and reform of supply side. (4) Enhancement of technical and allocative efficiency and minimization of all forms of losses. (5) Enforcement and emphasis on demand management strategy. (6) Encouragement of the use of new and renewable sources. (7) Implementation of energy conservation strategies. (8) Encouragement of private and public sectors investments (involvement) in energy sector. (9) Promotion of information systems. (10) Encouragement of hydroelectricity generation. (11) Removal of all technical and financial constraints facing the exploitation of domestic oil products and encouragement of foreign capital involvement in domestic exploitation.

ملخص الدراسة

تعتبر الطاقة هي القوة المحركة لكل النشاطات البشرية ، حيث أنها مدخل رئيسي وضروري لأهم القطاعات المنتجة والتي تساهم في تغطية الاحتياجات الفردية والجماعية .

في إطار استراتيجية التنمية المستدامة ، تكتسب مصادر الطاقة أهميتها لأن التنمية الاقتصادية ترتبط بنمو إستهلاك الطاقة ، ولأهمية وخطورة الآثار البيئية المتعددة التي تصاحب إستخدامات الطاقة وصعوبة معالجتها .

خلال العقود الماضية، ساهم نقص الطاقة للقطاعات المنتجة في الاقتصاد وبشدة في الأزمة الاقتصادية الحالية بالسودان وتسبب في ضعف الاداء الاقتصادي ، وادى نمط الاستهلاك والطلب وهيكلية قطاع الطاقة دورا مهما في تفاقم الكوارث والتدهور البيئي في السودان

إستخدمت الدراسة الحالية « المنهج التحليلي التجريبي » وثلاث طرق مختلفة للتحليل شملت التحليل بالرسم البياني والتحليل الاحصائي – الرياضي وفيه استخدمت الدراسة الحاليه طريقة المربعات الصغرى واستخدمت صيغة الدالة اللوغريثمية لتقدير معادلة الطلب وتقدير المرونة السعرية والدخلية علي المستويين الجزئي والكلي . كما استخدمت الدراسة المعادلات الآنية لاختبار الفرضية التي تزعم ان السعر محدد داخلي في تحديد نموذج الطلب على واردات البترول ، واستخدمت الدراسة طريقة المربعات الصغرى (المزدوجة)– ذات الخطوتين لاثبات الفرضية التي تزعم أن الطلب على واردات البترول في السودان خلال سنوات الدراسة يتحدد أو يعتمد على وجود العملات الصعبة .

واستخدمت الدراسة الحاليه برامج تطبيقية للحاسوب في التحليل الاحصائي الرياضي والتحليل بالرسم البياني . « تطبيقات برنامج النوافذ ».

ركزت الدراسة الحالية علي جانب الطلب لأن طبيعة مشكلة الطاقة في السودان تعزى أساسا لمشكلة فائض الطلب وركزت الدراسة على التحليل الاحصائي الجزئي والكلي لدالة الطلب القطاعي والكلي لأنواع الطاقةالمستخدمةفي السودان .

من نتائج الدراسة أن كل المعادلات المقدرة أظهرت طلب غير مرن بالنسبة للأسعار على المستويين الجزئي « القطاعي » والكلي « التجميعي ». وأظهرت نتائج المعادلات المقدرة قلة المرونة السعرية في كل المعادلات المقدرة ، وهذا مؤشر على أن السياسات السعرية غير فعالة أو قليلة الأثر لإدارةالطلب على الطاقة في السودان لأن الطلب على الطاقة قليل التأثر و الاستجابة لتغيرات السعرخصوصاً في معادلات طلب القطاع السكني (المنزلي) على الكتله الحيه وطلب قطاع

المواصلات على البنزين والجازولين . معظم المعادلات المقدرة كانت معنوية احصائيا وفي معظم الاحيان كانت متفقة مع الافتراضات النظرية التي تزعم أن منحنى الطلب على الطاقة سالب الميل .(ماعدا معادلات طلب القطاع السكني (المنزلي) على الكتله الحيه وطلب قطاع المواصلات على البنزين والجازولين حيث اظهرت نتائج الدراسه أن منحنى الطلب لهذه الدوال موجب الميل نتيجه للدعم السعري خلال سنوات الدراسه).

في معظم المعادلات المقدرة كانت الطاقة سلعة عادية لأن المرونة الداخلية كانت موجبة واقل من الواحد الصحيح مما يدل على أن الطاقة سلعة ضرورية للقطاعات المستهلكة في السودان . وفي معظم المعادلات المقدرة كان الطلب قليل الاستجابة للتغيرات في الأسعار والدخول وفي معظم المعادلات كان الاثر الدخلي يفوق الاثر السعري .

أثبتت الدراسة الحالية ان الطلب علي واردات البترول في السودان يتحدد معنويا بوجود تدفقات العملات الصعبة .

أبانت الدراسة الحالية أن استهلاك الطاقة «اجمالي الطاقة والطاقة التجارية» للفرد في السودان يعتبر الاقل مقارنة بالدول النامية الأخرى ، كما أبانت الدراسة أن هنالك نموا معتبرا في اجمالي استهلاك الطاقة والطاقة التجارية والاستهلاك الفردي للطاقة التجارية وكذلك نمواً طفيفاً في الاستهلاك الفردي لاجمالي الطاقة .

من جهة أخرى فقد أثبتت الدراسة أنه علي الرغم من أن قطاع الطاقة في المتوسط قد استحوذ على ١٥,٤٤٪ من اجمالي منصرفات التنمية خلال الفترة « ١٩٨١-١٩٩٤» إلاأن مساهمة قطاع الطاقة في إجمالي الدخل القومي كانت ضعيفة وهامشية وفي المتوسط لم تتعد ٢,٥ خلال الفترة «١٩٨٠-١٩٩٠» حيث كانت مساهمة قطاع الكهرباء والمياه خلال نفس الفترة تتراوح ما بين ١٪ - ٢,٣٪ .

أكدت الدراسة على أن الاعتماد الكبير على البترول كأحد أهم مصادر الطاقة التجارية في السودان كانت له آثار خطيرة على الأداء الاقتصادى . وابانت الدراسة علي أن الاعتماد على استيراد البترول ساهم وبشدة في زيادة معدل التضخم عن طريق التأثير المباشر في المستوى العام للاسعار وتكاليف السلع المصنعةداخليا والمعتمدة على واردات البترول .

قياسا على نتائج الدراسة أوصت الدراسة الحالية بإتباع سياسات تهدف الى :

١- تطبيق استراتيجية شاملة ومتكاملة على المستوي القطاعي ، الاقليمي والقومي .

٢- تقويم ومراجعة النظام السعري .

٣- زيادة العرض وحل المشاكل المتعلقة بجانب العرض وامدادات الطاقة.

٤- تطوير وزيادة الكفاءة التقنية والوظيفية « التشغيلية » وتقليل الفاقد بصورة المختلفة .

٥- التركيز على تنفيذ استراتيجية ادارة جانب الطلب .

٦- تشجيع استخدام المصادر الجديدة والمتجددة.

٧- تنفيذ إستراتيجيات المحافظة على الطاقة .

٨- تشجيع استثمار القطاع العام والخاص والمشاركة في تطوير قطاع الطاقة

٩- تطوير نظم المعلومات .

١٠- تشجيع استخدام الطاقة الكهربائية المائية.

١١- إزالة كل العقبات التقنية والمالية التى تحد من استخراج واستغلال البترول السوداني وتشجيع رأس المال الاجنبي للمشاركة في استخراج البترول السوداني.

TABLE OF CONTENTS

Table of Contents

List of Tables and Figures

(1) List of tables

Table

No. **Page**

(2) List of Figures:

CHAPTER ONE

INTRODUCTION

بسم الله الرحمن الرحيم

Chapter One

1.1 Introduction :

Energy “The Capacity to do work”, obviously influences economic well being (Denis Hayes in Manass Chatterji 1981 P.28). Because it is considered the driving force of all human activities. Energy plays an important role as a key productive input in the key productive sectors which provide many individual and collective needs. Thus it is an indispensable input and prerequisite for sustainable development and growth pattern of the developing countries.

In the context of sustainable development strategy the Western development pattern suggests that “the importance of energy and environment in the economic, social and political structure of the developing countries cannot be overemphasized, but the rationale assessment of energy demand and supply balances can only be undertaken on a global scale and must therefore take due account of a global inter-dependencies. Both energy and environmental issues are very much part of the current “North-South” debate”. (Manas Chatterji 1981 P.(xi)). According to William and Toufiq, “energy and environment are interrelated simply because societies are absolutely dependent on the natural environment to meet most human needs, including the need for energy”. (Manas Chatterji, 1981 P.53). Energy derived from various sources such as biomass (which include fuel wood and charcoal), coal, oil (fossil fuel), nuclear power and electricity (hydro or thermal power). “According to Peter Nijkamp and Frans Kutsch Lojenga natural resources, energy and favourable physical conditions are prerequisites in the stable growth pattern of a typical developing country”. (Manas Chatterji 1981 chap.(14) P. 245).

Sedar and Suleyman (1995) pointed out that "Environmentally and Economic sustainable development requires a balance between economic growth targets and a healthy environment so as to improve the quality of life for the present and future generations. By their very nature contributing both to environmental degradation, resources depletion, economic growth and development, energy issues are keys to this balance. The challenge is to find a way to minimize the energy-related environmental cost of development without frustrating economic growth". According to them consideration of energy issues are critical to the achievement of such balance for two reasons, first, in the broadest sense of the term, energy is an essential input for virtually all industrial production process. Second, both wide spread use of certain types of energy as an input and various technologies employed in the generation of energy itself inflict considerable damage upon ecological process in the form of environmental pollution. Hence the production and consumption of energy are among the prime factors behind the current degree of environmental degradation and natural resources depletion in many countries including Sudan.

The present chapter of the present study is an introductory chapter about the research objectives, significance, nature of the problem, data sources and methodologies.

1.2 The objectives of the study:-

The present study aims to achieve the following objectives:-

1) To identify the critical relationship between economic output and energy use (consumption) i.e. correlation between economic development and energy use.

2) To explore the nature of energy crisis in the Sudan, its causes, determinants, implications (economic impacts) and the possibilities of alternative solution.

3) To contribute to the process of timely energy planning in Sudan. "The achievement of near and long term development objectives requires that energy resources of proper type and magnitude be available to sustain various sectors of the economy".(Phil O'keef, et al 1984 in (EEDA 1), p.1)

4) To explain the current energy flows in the Sudan. (Considerable quantitative analysis is given about the structure) and the sources of energy in Sudan.

5) To estimate energy demand equation at macro and micro levels disaggregated by different sectors. The study focuses on the demand side for its significance in the determination of energy sector structure. And to estimate the prices and income elasticities.

6) To investigate how energy crisis in the Sudan might constraint sustainable development objectives through their critical impacts on environmental degradation.

7) To explain how the lack of foreign exchange receipts might affect energy sector flow and the economic progress in the Sudan (i.e. how foreign exchange availability constraint the demand for petrol imports and therefore constraint long term sustainable development objectives).

8) To explain the impact of economic policy on energy sector flow and how effective policy instruments and economic measures and policies such as supply side reform, demand management, taxes, regulation and rationalization programmes and pricing system adjustment are useful to solve or even alleviate the current energy crisis.

1.3 The significance of the study :-

1) It is significant to understand the structure, flow, sources and nature of energy in the Sudan since energy sector is a key productive input on which all human (among them economic) activities depend i.e. energy input is significant in modern economics. It is an input to any commodity produced, even in rural and primitive societies energy constitutes basic need. Thus energy crisis assumes to affect over all economic and human activities in the Sudan.

2) Economic development objective in the Sudan is largely affected by energy shortage especially commercial energy (petrol and electricity). Thus energy sources are necessary or strategic element for both food security and long term objectives of economic development.

3) It is necessary to deal with energy, because "the currently important energy resources are non renewable resources, which when used as energy sources cannot be recycled. Moreover, the extraction and usage of the currently important energy resources is a major source of environmental pollution, i.e. the production, transportation, storage and other ways of energy use directly or indirectly affect environment". (Michael Common 1988).

4) It is important to understand the structure of energy demand through final (usage) consumption by different sectors, because demand (consumption) pattern is an indicator for development and for long term planning objectives.

5) It is significant to understand how the foreign exchange availability affect the flow of commercial energy (petrol and oil) and therefore constraining all economic activities. In addition to the implications of the increase of oil imports prices or costs on the balance of trade and the balance of payments.

1.4 The Nature of the problem :

The National-Energy plan (NEA 1985: 1-12: NEA. 1982: 14 Callaghan 1985), pointed out that energy shortage and unreliable supply can cause damage to the economy and to the quality of life. It is pointed out that the Sudan faces two main problems with regard to energy.

"Firstly: there is a lack of foreign exchange for the import of petrol, which is at present mostly used for transport, and increasingly also for electricity generation both localized mainly in Khartoum (NEA 1985 a*: 22,18, NEA. 1982 a*: 9, 34). The result is a vicious circle: Lack of hard currency with which to buy energy input for example for agriculture, lead to a decline in exports, which leads to a further lack of hard currency". (C.de. Jong- Boon, 1990 Part (I) PP. 253-254).

"Secondly: Forests will disappear from the Northern and Central provinces by the year 2000 (NEA 1985*: 63, 31-3, 38-59 chap. '2'). The supply of wood and charcoal which at present constitute about 80% of final energy consumption, most of this is used in the households (cooking) and smaller part in industries such as Khartoum brick-making and bakeries (Ahmed and El Magzoub 1985, Abdel Salam 1986 b)". (C.de. Jong- Boon, 1990 Part (I) P. 254).

"There is of course a link between the two problems, lack of imported fossil fuel due to lack of foreign exchange forced people to turn to wood and charcoal, the consequences of desertification become serious, it has been estimated that energy consumption (for cooking) causes 92% of all desertification in Sudan, and is therefore largely responsible for the consequences and deterioration and lack for fodder (Whitney, et al 1985: 14-15 chap.'2' and '5'), on the other hand desertification and destruction of the food production base are more threatening (Shaik and Karch 1985)". (C.de. Jong-Boon, 1990 part (1) p. 254).

1.5 The Methodology :-

The methodological approach of the present study is analytical and empirical in nature. In the first part an analytical approach is used to identify the role of energy and its relation to economic development.

Both descriptive and analytical approaches are used to explore the research problem. In addition to, an empirical models are adopted and econometrics techniques are used in two ways by using the system of regression equations.

A) Firstly a single-equation model is adopted in attempt to estimate energy demand equation:

$Q_d = a + bY - cP$ where a, b and c are parameters

Q_d : is quantity of energy consumed. (Under the assumption that Q_d represents real value)

P : is relative or real price of energy to final users.

Y : is GDP (real) at factor cost.

The ordinary least squares (regression method) will be used to estimate energy demand, income and price elasticities..

B) Secondly to estimate the proposed effects of a macroeconomic policies on energy sector. The present study will attempt to estimate the demand for petrol imports subject to the constraint of foreign exchange receipts availability. Under the assumption that imports prices are endogenous, simultaneous-equations technique is used to assess and estimate the demand. Using two independent structural equations (supply and demand), an import supply curve assumed to be inelastic with respect to price and the demand curve is a normal downword sloping demand curve.

Two structural equations are used (in log-form):

$\ln M^d_t = a_0 + a_1 \ln (P_m/P)_t + a_2 \ln Y_t + a_3 \ln m_{t-1} + U_t$ (demand equation).

$\ln M^s_t = b_0 + b_1 \ln F_t + b_2 \ln R_{t-1} + b_3 \ln m_{t-1} + b_4 \ln (P_m/P)_t + V_t$ (supply equation)

where M^d_t, M^s_t are demand and supply equations respectively, $M^s_t = M^d_t = M_t$, in equilibrium $(P_m/P)_t$, M_t are endogenous variable U_t, V_t are normally distributed random variables (a_i, b_i, $i = {}_{1,2,3}$) are structural parameters which are identified.

M_t: Volume of petrol imports (using balance of payments data base). (Under the assumption that M_t represents real value).

$(P_m/P)_t$: Relative, real price of petrol imports (i.e. petrol price deflated by GDP deflator)

Y_t: GDP at market cost (i.e. real GDP) (using National account data).

F_t: foreign exchange receipts deflated by GDP deflator (using balance of payments data).

R_{t-1}: Lagged end year stock of foreign exchange reserves deflated by GDP deflator (using balance of payments data).

Imports demand equation cannot be estimated by OLS technique since this yield a biased and inconsistent estimates of the relevant elasticities. Thus a consistent estimate of the demand elasticity can be obtained by using a simultaneous-equation procedure such as two-stage least squares estimate (2SLS). Time series data and cross sectional data will be used when availble.

1.6 Sources of data :-

The necessary data for the present study are collected from different sources.

1) Primary sources of data are used when available.

2) Secondary sources of data are used as follows:-

i) Reports and studies of the Ministry of Energy and Mining and National Energy Administration.

ii) Published data and materials of different conferences related to the study which are available in the U. of K. libraries.

3) World Bank Publications.

Two types of information are used in this study to estimate the demand function.

i) cross sectional data when available

ii) Time series data.

The study basically depends on document sources of data, these include the available published data (books, papers and magazines) dealing with energy crisis and sustainable development.

Statistical data are useful to the estimation of the demand equations.

These sources provide a valuable information about the flows, intensities of different energy sources, about the energy crisis, their reasons, impacts and possibilities for solution.

CHAPTER TWO
ENERGY AND DEVELOPMENT

Chapter Two

Energy and Development

Introduction:

Since energy is important element for the achievement of sustainable development objectives in the developed and developing countries ,the present chapter begins with the definition of the concept of sustainable development and its relation to energy field. This is followed by the identification of the relationship between energy and development in the second section. The third section examines and explains the environmental impacts associated with different energy use. The last section focuses on the nature of energy problem in the less developed countries.

2.1.1 The Concept of Sustainable Development : -

"Recently, sustainable development appears in development literature to replace many concepts such as growth, modernization, progress and even accelerated development as the unifying concepts for world wide development activities. It has been argued that, the concept of sustainable development represents a fundamental, more broad and lasting contribution to development theory and practice, since the concept has succeeded in unifying widely divergent theoretical and ideological perspective into a single conceptual framework. Moreover, the concept provide a new strategy for national and international development". (Richard J. Estes PP. 1-2, 1993).

It has been evident that, development theories during the period (1940s-1950s), in the industrialized countries focused on growth and efficiency objectives. In the 1960s, the consideration of social issues like poverty and income distribution became vital and therefore a considerable efforts devoted to consider or to include these issues in the context of equitable growth model. In the early 1970s environmental issues received particular attention and awareness, this lead to increasing interest to consider them to achieve environmental balances and sustainable development objectives. Since then economists paid especial attention to the environmental problems and other related socio-development issues. On the other hand, the OPEC-oil crisis of (1973-74) helped to focus attention on question about the availability of (natural resources) energy resources. In the 1980s development models are broadened to include the concept of sustainable development. According to Richard, J. Estes (1993), the concept designed to resolve the acute crisis concerning the failure of existing models of development to offer effective and lasting solution to recurrent and worsening problems of the less development countries, i.e. to offer at least general guidance to these countries seeking to accelerate the development and self-sufficiency. According to the World Bank (1990), sustainable development has become a key catch phrase in economic planning and resources management, the idea of sustainable development has dominated most recent discussion on development and environment.

2.1.2 Sustainable Development :-

"The concept of sustainability has come to mean different things to different people in different situations. Generally it is defined as development without destruction, i.e. development which does not destroy the available resources and environment base on which it depends". (Baha Eldin M. A. Taha 1993).

"Following the definition of Dover and Talbot (1987), the term sustainable energy means energy flows that keeps and continues its optimum productivity in definite period of time, then the term broadened to incorporate an ecological aspects, through the idea of maintaining an average level of energy output over an indefinitely long period of time without depleting the resources or degrading the natural environment". (Baha Eldin M. A. Taha 1993 chap.(3) PP.46-47). "Warren, Agnew (1988) emphasized this definition, while Conway and Barbier (1988), put it differently "The common use of the word 'sustainable' suggest an ability to maintain some activities in the face of stress." Therefore sustainability depends on the properties of the system or resources, the nature and the strength of the stresses and shocks and the way, systems and resources are managed and shocks countered". (Baha Eldin M.A. Taha 1993 chap.(4) P.57).

David Brown (1991), distinguished between four dimensions of sustainable development ecological, economic, political and cultural sustainability, according to him ecological sustainability implies that non renewable resources are not depleted for short-term improvement, economic sustainability implies that improvements do not depend on continuing infusions of resources that cannot be maintained. According to Brown, effective approaches to sustainable development must optimize the use of resources that are available locally, minimize dependence on resources that must be brought in from outside and must not seek improvement for which continuous infusion of existing or new resources are needed and must converse those resources that are needed for improvements over the long term. (Richard, J.Estes 1993 p. 10).

"According to Hermany Daly (1991), renewable resources should be exploited on a sustainable-yield basis. The choice among many levels of sustained yield can be made on the criteria of profit maximization (sustainable yield base). Non renewable resources have no sustainable yield at least on time scales relevant to human experience. John Ise (1920) pointed out that, non renewable resources used up at such a rate that its price will equal to the price of its nearest substitute or resources should be priced according to their long-run replacement cost".(Davis, Bernstam. 1991.)

The World Commission on Environment and Development (WCED) (1987), defined sustainable development as paths of social, economic and political progress that meet the needs of the present without compromising the ability of future generations to meet their needs (i.e. provided the material wants of the present generations without depriving future generations of the resources required to satisfy their needs), i.e. the plan and the tools which are designed for development must also consider the environmental management objective so as to avoid resources depletion. Humanity have enough resources to control the dangerous deterioration of the environment. (WCED.1987).

"In an attempt to make Brundtland (1987) definition operational, Hermany Daly (1991), raised two questions. First the needs of the present require some distinction between basic needs and extravagant wants. Sustainable development is about sufficiency as well as efficiency. Second, the ability of the future generations to meet their own needs may be interpreted as requiring either strong or weak sustainability".(Davis, Bernstam. 1991).

According to Brundtland (1987) Report, sustainable development is the process of change in which the exploitation of natural resources - the direction of investments, the orientation of technological development, and institutional change are all in harmony, and enhance both current and future potential to meet human needs and inspiration. In this way Nijkamp (1990), considered sustainable development as "a balanced and adaptive process of change characterized by pareto optimal trajectory in which progress in one system that is either the economic or the ecological wouldn't be to the determent of the other system. It stresses that, in the short rum,environmental and economic goals, both on regional and global scales are often mutually conflicting.However, in the long run, consistent with the concept of sustainability, a situation of mutual complementary of coevolution can emerge".(W.B.1990 p. 6). "In the short run -sustainable development requires a careful consideration of sustainable threshold levels of both economic and environmental systems".(W.B. 1990).Moreover,"according to Mustafa Kamal (1985), the United Nations-Environment-Programme(UNEP) (1973) emphasized the fact that environment and development are closely interrelated,and development cannot be sustained without explicit consideration of its impact on the environment and similarly a good environment and quality of life cannot be achieved without appropriate development".(Yehia and Asit 1985) .

According to Mustafa Kamal (1985) one of the most important components of the environment -development interrelationship is energy. The oil price increase in 1973 revealed the close interrelationships between energy availability and use and environment and development. This raised the call for more rationale management of energy resources and conservation practice to contribute toward improving environmental quality. (Yehia and Asit 1985).

According to WCED (1987), "Energy Supply and Consumption pattern, ultimately can determine the capacity of this planet to sustain the life support systems on which all other development depends. There is no doubt that today certain energy pattern threaten the sustainable development of the countries or regions in which they dominate. This is clearly true for fuel wood crisis". (WCED. (1987) - Energy (2000) p. 5).

According to WCED. (1987) and FAO. (1980), "1300 million people lived in wood deficit area (satisfy minimum needs, but only through unsustainable over cutting) and over 116 million in acute scarcity areas (defined as area where even with overcutting people cannot satisfy minimum needs).The same study projects that by the year 2000 about 3,000 million may live in deficit and acute scarcity areas, thus causing increased deforestation, erosion, desertification and diversion of plant and animal wastes from soil replenishment".(WCED.(1987). Energy- (2000) P.5).

"The WCED. (1987), emphasized the fact that certain pattern of energy consumption could undermine sustainable development in a global basis. Climatic change has now emerged as a serious and plausible threat to the economic and social development of nations and could place intolerable burden on world wide political stability within the next years". (WCED. (1987) - Energy (2000) P. 6).

"Environmentally sustainable development requires a balance between economic growth targets and a healthy environment so as to improve the quality of life for the present and future generations. By their very nature contributing both to environmental degradation resources depletion and economic growth, development, energy issues are key to this balance. The challenge is to find ways to minimize the energy related environmental costs of development without frustrating economic growth. Thus consideration of energy issues is critical to the achievement of sustainable balance for two reasons, first in the broadest sense of the term energy is an essential inputs for virtually all industrial production process. Secondly both wide spread use of certain types of energy as an input and various technologies employed in the generation of energy itself inflict a considerable environmental pollution. So the production of and consumption of energy are among the prime factor behind environmental degradation and violation of sustainable development objective". (Sedar and Suleyman, 1995).

<u>2. 2 Energy and Development :-</u>

Recently energy related issues have received a considerable attention in both the developed and developing countries, particularly after the increase of oil prices in 1970s. "It has been recognized that energy crisis during the 1970s is not a transitional phenomenon since it transmitted or shifted the world from cheap energy prices period, into increasingly expensive energy prices period. Energy inputs become expensive and its role increases and become equal to the classical factors of production (like land, labour and capital). Since then in many parts of the world there is a growing concern or awareness that some alternative energy sources could have an important role to play in the process of economic development". (W.B. 1980).

In the developing countries the 1973 oil crisis, increased the awareness or the importance of energy sources for economic development. "Edelman (1981) examined the severe difficulties in most of the lesser developed countries resulting from the sudden termination of the period of cheap oil and natural gas. It was feared that the high prices of energy would lead to the collapse of the economy of those countries (Manas Chartterji 1981 p. 22).

In both developed and developing countries the relationship between energy and economic development is important, because the process of growth in the productive sectors of each economy are closely interrelated to the availability of energy resources. Thus energy related issues are extremely important and significant.

According to WCED (1987), "the patterns of energy supply and consumption can widen the opportunities for future economic and social development or they can constraint them, in some cases eliminating them altogether, they can provide the basis for a high and sustainable level of security and comfort, or they can destroy it, reinforcing insecurity, wide-spread misery. Ultimately, they can determine the capacity of this planet to sustain the life support systems on which all other development depends". (WCED. (1987) - Energy (2000) p.5).

Historically economic development has been linked to increasing energy consumption per-capita, the experience of the industrial World indicates that, as economic development progress, energy consumption per-capita rose. Thus under development and low energy use are interrelated i.e. deficiency in energy supply makes economic development difficult".(Leonard Berry and Richard Ford. 1978 (EAETPP)).Therefore, the availability of adequate food supplies for both domestic consumption, and for industrial progress has become closely interrelated to or determined by the costs and availability of energy, energy capacity and the potential increase of supply.

"In most African countries, industrialization and development planning is a more recent phenomenon , they are characterized by lowest energy consumption. The high energy growth rate, date back only to the late of 1950s. The coefficient of energy use during that period was approaching 2% which implies that each percentage rise in economic activity brings about a 2 percent rise in energy use. This coefficient may be compared with a figure of 0.7 to 0.85 for the USA and Western Europe respectively in the late 1950s. The high percentage growth rate in energy consumption for the under-developed countries during 1972, was about 15%, of the non-communist world, although they accounted for 75% of the world population. It has been claimed that, as the process of industrialization in the less developed countries continues, given the positive relationship between economic growth and energy (intensity) consumption and flows, the share of these countries in total world energy consumption will rise relatively faster than that of industrial world. According to Figure (2-2) estimates of the global supply-demand integration indicated that under developed countries could consume as much as 25% of total world commercial energy by the year 2000. (Waes 1977), figure(1.3),p.4".(Leonard Berry and Richard Ford. 1978 (EAETPP). PP.2-3).

According to the World Bank Report (1980), "the total energy consumption in the developing countries constitutes a very small part of total world energy consumption, but it rose by a faster rate than the previous decade. During the twenty five years preceding the 1973 oil shock, the ratio of GNP, annual growth rate to the demand for energy was 1.3:1, however, due to the sudden increase in oil price during the period (1975-1980), the ratio declined to 0.8:1." (W. B. Report 1980 chap.(1)).

"It has been emphasized that energy provision is one of the most fundamental prerequisites or aspects for development. In both developed and developing countries, there is some evidences that commercial energy consumption and the level of development are positively correlated. Several studies have emphasized the fact that the consumption of commercial energy form like electricity and fossil fuels increases with the increase in economic development, and at the same time, the consumption of wood fuel, dung and crops residues decrease. This resulted in both a higher total and per-capita energy consumption. Moreover, energy is required to increase labour productivity associated with industrial development. Energy provision is vital to the development process even at the subsistent level". (W.B. 1979).

"The basic correlation between economic output and commercial energy consumption could be illustrated by figure (2.1) where per-capita energy consumption is plotted against per-capita GNP for each country. The figure depicts only the commercial energy forms (coal, petroleum, natural gas, hydroelectric and nuclear) in energy/output relation, due to limitation of availability of reliable information on the so called non commercial sources (primary wood based fuels, animal dung and agricultural residues). In the developing countries over 80% of rural energy is derived from wood and animal waste and is primarily used for cooking and agriculture. Most of energy used is non commercial and produced by people themselves (by primitive means) to meet their own needs. In those countries commercial energy provides only a small part of their total energy consumption. According to Figure (2-1), there is a positive relationship between commercial energy use and the level or degree of development. Generally developing countries consume less than 20% of total commercial energy although they have more than two thirds of the world population. The figure also indicates the wide variations in the pattern of development among the less developing countries which lead to a substantial spread in the relationship of energy output. The OPEC countries of course have special status. But even within the non-OPEC LDC's, such factors as the level and type of industrialization,the availability of indigenous energy source, and the role of primary and agricultural exports play an important role in determining the precise energy requirements for growth". (Phil O'keef, et al 1984 in (EEDA 1) chap.(2) PP.7-8).On the other hand, Mudassar Imran and Philip Barnes argued that, "the distinct differences between energy intensities among the developing countries, could be attributed to the factors such as the structure of their economies, their fuel mix, activity level, their climate and pricing policies". (W.B. 1990.P.(V)).

"During the period of (1960-1972), underdeveloped countries more than doubled their consumption of commercial energy and increased their demand for electric power by more than 250 percent. The lower income countries consumed only 25% of world commercial energy in 1972, i.e. less than $200 per capita (Waes . 1977). In these lower income countries per-capita elasticity of energy demand is about 40% higher than the corresponding total income elasticity.On the other hand, the industrialization process that raises the per-capita income also resulted in a gradual reduction in growth rate of energy consumption with respect to growth in real income. Estimates of percentage decrease in the income elasticity of energy for the lower income countries expects a percentage rate between 8 and 13 percent by the year 2000. This estimation anticipated that lower income countries will increase their energy consumption by 3 or 4 times the 1972 level , if rates of economic growth between 4 and 5 percent per year are achieved.(Waes. 1977)".(Leonard Berry and Richard Ford. 1978 (EAETPP). PP.5-6).

According to Mudassar Imran and Philip Barnes,"estimation of energy consumption increased rapidly in the developing countries. It is estimated that the share of the developing countries in global energy consumption outside the centrally planned economies increased rapidly from 20% in 1972 to 33% in 1988. It is anticipated that these energy consumption trend will continue. They anticipated that around two thirds of the incremental energy demand in countries other than communist countries is likely to occur in the developing countries with their share rising sharply to over 40% by the turn of this century". (World Bank 1990 PP. 1-2) .

The pattern of energy use and consumption reflects the degree of development. "This fact emphasized by Earl (1975, 6), according to him economic progress is governed by energy law. Nevertheless until recently energy issues were largely ignored by the development economists, who prefer to concentrate mainly on problems of industrial growth, mining, import substitution and food production". (R.P. Moss and W.B. Morgan 1980 p.17). "(Earls 1975, 10) suggested that over 90% of energy requirement is supplied by woods in Nepal, Tanzania, Nigeria and Uganda".(R.P. Moss and W.B. Morgan 1980 p. 21). On the other hand, "J.O. Ladipo-Adjuwon pointed out the results of rural survey show that as many as 96.7% of all rural household in Nigeria rely on fuel wood for cooking".(Yehia and Asit 1985 p.118) . "H.H. Scheiders in Tanzania estimated that about 90% of energy consumption is based on fuel wood". (Yehia and Asit 1985 p.155). This lead to a very dangerous situation of deforestation and environmental degradation. "According to Salah Arafat, in Egypt the component of per-capita gross energy consumption from both conventional and non conventional sources in rural Egypt is as follows: 64.8% from crop residues, 12.4% from cattle dung, 18.4% from kerosene, 2.8% from Butagas and 1.7% from electricity".(Yehia and Asit 1985 p.134). Comparing this figure with Sudan according to Hassan Abdel Al Nour (1989), fuel wood accounting for 82% of total energy supply(E.M.Abdelatif. 1993 P.23). This has been emphasized by N.E.A statistics in (1989/1990), fuel wood accounted for 80.5%, petrol accounted for about 11.9%, electricity about 7.2%, and other sources accounted for 0.4% of total energy supply (E.M.Abdelatif .1993 P.109).

"According to Mustafa Kamal, the scenario of low energy capacity in the developing countries is attributed to the fact that either commercial forms of energy are not easily available, or the people concerned do not have the economic power to purchase them on a regular basis for various activities, ranging from cooking, lighting, to various agriculture, and other economic activities". (Yehia and Asit 1985). "These resulted in the fact that most African countries are particularly low on both the energy and GNP scales. Low levels of energy and low level of agricultural and industrial production per head. A low level of development in turn limits the use even of available energy and restricts both the choice of fuels and the introduction of more modern flexible forms of energy supply. The optimistic view in this way is that rural energy problem in the third world would be solved by the development process itself".(R.P. Moss and W. B. Morgan 1980 P.4).

2.3 The Environmental Impacts of Energy Use:-

"Energy is directly related to almost major aspects of modern human activities, like the production of food, the provision of shelter and the transportation of goods. There are also numerous indirect linkages between basic energy process and human activity and these arise from the increasing demand for energy and the pressures of these processes on the environment".(Perkowski (1976), in William and Toufiq in Manas Chartterji (1981) P.56).

According to Manas Chatterji (1981), recently both energy and environmental issues, considered as part of the current "North-South" debate. Both of them are considered as means for attaining society's material and non material goods. "Well planned use of energy generally contributes to the well being of societies, its misuse or over use can lead to poorer health and other undesirable effects. On the other hand good management of the environment helps to preserve the ecosystem, and thereby contributes positively to meet the needs of society. Mismanagement of environment resulted in exhaustion, degradation and pollution and therefore affecting the society's well being for both current and future generations". (William and Toufiq in Manas Chatterji 1981 pp.57, 64).

"The interrelationship between energy and environment could be understood from the fact that societies are absolutely dependent on the natural environment to meet most human needs (both individual and collective) including the need for energy. However, due to the difficulties of getting accurate perspective on environmental dimensions of energy policies and the recent history of awareness of these relation, there is a confusion, in addition to a lack of basic scientific and technical knowledge on key issues related to energy-environmental considerations, create uncertainties which create difficulties to decision-makers. Therefore trade off between environmental considerations and energy requirements become important". (William and Toufiq in Manas Chatterji 1981 p.53).

"In most parts of the world the vital role of energy in industrialization progress and in increasing living standards until the mid of 1960s did not create any opportunity or concern for any environmental consequences of energy production or consumption. However, in the mid 1960s there was increasing public awareness that certain approach to energy production, transportation and consumption have a considerable undesirable environmental effects. Though, the first concerns were expressed in terms of loss in health life, food security and comfort which are classified under the environmental considerations. In 1972 the United Nations Conference on Human Environment in Stockholm represented a very important step in increasing the awareness and commitment to deal with environmental related issues" (William and Toufiq in Manas Chatterji 1981 pp. 53-54).

"According to C. Anthony Pryor, the production and consumption of energy can cause serious environmental consequences. Environmental consequences of energy production can be considered to have both an impact on the environment as an amenity and as an input into production, and hence is not simply a matter of amenity loss. In this way distinction has to be made among production of an energy resources (such as extraction of coal), the transportation of energy (such as pipeline or power line), the generation of energy and finally the consumption of energy. Conventional fossil fuels like coal, and oil, may have a serious environmental problems related to extraction, these may be in terms of amenity loss in the destruction of wilderness, or in terms of loss of productivity through strip-mining or seepage of oil. On the other hand, the generation of electricity may also cause serious environmental problems. These problems often relate more to the side effect of the generation system than to electricity generation process itself". (Manas Chatterji. pp. 131-132). According to William and Toufiq, the hydroelectric dams also have a serious environmental impacts, such as the destruction of wilderness and the potential increase of deforestation in the surrounding regions. Large hydroelectric irrigation projects cause internal migration which may increase deforestation and also help spread water-related diseases like schistosomiasis. In this respect the sources of these problem is not the generation of electricity, but rather the impact of such schemes on the surrounding water shed. On the other hand, the hydroelectric power project may cause change in land use patterns and local ecosystem, the major affected groups are owners of land displaced, farmers and others affected by dam construction and operation and water users. The major environmental concern of geothermal power projects is the disposal of salt and gases into river, lake or ocean, in addition to noise". (Manas Chatterji 1981 pp. 63-64).

"According to C. Anthony Pryor, nuclear power also have serious environmental impacts such as radioactive wastes accidents, these affect nuclear power industry and other industries including uranium, mining, electric control, and also affect people living close to the power plant. Nuclear power have serious implications on safety and health, in addition it represents a risky and dangerous weapon in both developed and developing countries". (Manas Chatterji 1981 p.132).

The WCED. (1987), raised the environmental issues related to energy use, the report demonstrated that, the increase in consumption of fossil fuel and coal resulted in more than doubling of the production of carbon dioxide, which would bring the world closer to possible major climatic changes such as the green house effect, increased fossil fuel combustion in power station as well as in automobiles would also aggravated the acid rain problem in both industrialized and developing countries. This lead to sterilization of lakes in Europe, and more recently of soil, in addition to air pollution, nitrogen and sulphur oxide which threatened sustainable development. (WCED. 1987- Energy (2000)).

In the developing countries like Sudan, the major environmental concerns are related to traditional fuel wood, since it represents the major energy source in these countries. The increasing demand for fuel wood especially in rural areas where few alternatives are available, has resulted in serious environmental damage i.e. widespread deforestation and desertification. "According to Eckholm (1976 p. 222), the well known effects of such loss of trees cover, include the loss of top soil erosion, the silting of dams and canals increased floating, over the long term there is also expectation of a climatic change in the area. These may include change in the rest of ecosystem and also a possible loss of fertilizer from ecosystem, these may cause damage to soil structure. Moreover, exploitation of animal and plant wastes as substitute for fuel wood, in the developing countries is detrimental to soil fertility, depriving it of the essential plant nutrients and organic matter that are so important for its water and air retaining qualities. The major affected groups by such activities are farmers, residents of flood plains, producers and consumers of electricity, irrigation agencies. The major concern voiced by these groups are loss of income, loss of life, home and land and increases the cost of or price of electricity. In all these cases, the impacts have a tremendous development costs, for which society as a whole has to pay". (William and Toufiq , in Manas Chatterji 1981 pp.56-64).

"Solar and wind energy have fewer environmental problems and are non exhaustible energy sources. The constraint however, is that projects of these two types of energy sources are typically small-scale, and localized and therefore suitable for the surrounding areas. On the other hand the high costs involved in these sources form the key constraint to biogas, solar and wind energy (Paul Cough, Pers, Comm). But due to their lowest environmental costs, developing countries should start to use them directly and therefore, avoiding the problems associated with fossil fuel use. However, Agrawal and Stansell (1979) pointed out that care must be taken to choose proven technologies that have been well-tested under local circumstances and are economically feasible". (C. de. Jong-Boon, 1990 part (1) p. 252).

The environmental considerations of energy use in Sudan become more serious and sometimes reach the stage of crisis. "According to Younis and El Dawi (1986 chap.(2)), "petrol consumption which is concentrated in urban areas, causes pollution. Along the roads soil pollution results from the prevalent custom of changing motor oil too frequently (near Kassala), this threatened a water source, while Khartoum's power station, especially newest, ones contaminate the Nile with oil and heat". Thus shortage of petrol implies that pollution problems from this sources are diminished. As people turn to charcoal, however, the consequences of deforestation become all more severe, because of loosing fertilizers, when biomass is used as a substitute. It has been estimated that energy consumption (especially for cooking) causes about 92% of all deforestation in Sudan, and is therefore, largely responsible for the consequences of soil deterioration and lack of fodder (Whitney et al., 1985 pp. 14-15 chapt. (2) and (5)). On the other hand desertification and destruction of the food production base are far more threatening (Shaikh and Karch, 1985)". (C. de. Jong-Boon, 1990 part (1) pp 254-255).

"However, the serious environmental problems resulted from fuel wood consumption according to National Energy Agency (NEA, 1985) is that forests will disappear from the Northern and Central provinces by the year 2000. The supply of wood and charcoal which at present constitute 80% of final energy consumption used in household cooking and smaller part in industries such as Khartoum Brick making and bakeries (Ahmed and El Magzoub 1985 - Abdel Salam 1985 b)". (C. de. Jong-Boon, 1990 Part(1) p. 254). "According to WCED 1987, This threatened forests which is the front line in the ecosystem balance in any community or nation. Moreover, trees in rural area communities are an important source of livelihood for people, in particular, they supply fruits, fodder, fertilizers, medicines, poles for construction, shade and raw materials for a host of artisan activities". (WCED), 1987).

2.4 The Nature of Energy Crisis in the Developing Countries :-

In the developing countries like Sudan, energy shortage have significantly constrained the economic expansion. These countries witnessed rapid increase in the demand for energy, while the supply is stagnant or even diminishing, this created a serious problem because demand exceed supply. On the other hand, a limited generating capacity in a face of a rapidly increasing demand resulted in significant deterioration in the quality of power supply with serious implications in the performance of the national economy, social development and the welfare of the population.

"In most of the third world countries, the rural energy problem is concerned essentially with the maintenance and improvement of energy supply to satisfy the rapidly increasing demand". (R. P. Moss and W.B. Morgan 1980 p. 16). According to Mustafa Kamal (1985) the primary source of energy in rural areas is generally fire wood, the growing demand for fire wood from a rapidly increasing rural population has reduced its availability, fire wood scarcity starts a vicious social-economic-environmental-development cycle; because as the sources of fire wood within or near the village diminish, women and children have to spend more and more time searching for fire wood, and then carry the load collected over increasingly longer distances to their homes. This means that the time available to women and children to do productive work start to diminish". (Yehia and Asit 1985). ('Women and children spend two thirds of time searching for fire wood". (C. de. Jong-Boon, 1990 Part (2) chapt.(9)).

"This argument is supported by Curry Lindal (1979), according to him the developing countries are trapped in a vicious circle of lack of food and fuel on the one hand and deterioration of the environment producing these necessities on the other hand as a result of population growth, according to him in case of food and energy shortage, the population increase resulted in misuse or over exploitation or some times exhaustion of degradation or resources, this in turn exhaust productive environment which lead to increase in shortage of food and fuel and thus the cycle continues. On the other hand, Eckholm (1979) Sigal (1977), IUEN (1980), and Myers (1984) added another example of this vicious circles, according to them, the energy shortage (fuel wood) will result in deforestation, water retention diminishes and lead to flood and lack of water alternative in neighbour plain, this will decrease productivity of the (soil) land for both food and fuels. On the other hand burning of dung or crop residues lead to decline of soil fertility which decrease the land productivity. Moreover lack of food and fuel lead to population increase, because poor people usually do not limit family size and therefore, a vicious circle such as those described by Curry Lundal's occur". (C. de.Jong-Boon, (1990) Part (2) pp. 702-703).

"According to Yehia and Asit (1985), increasing demand for fuel food and charcoal, higher prices of kerosene, increasing demand for rural industries and agricultural production and higher population and competing demand for forests products, have all generated a rural energy crisis. This crisis can be understood only as an interaction of natural, technical and social factors, in this way energy sources cannot be addressed as an isolated physical or technical problem, but only in an over all broader context of development with its socio-economic, environmental and geopolitical dimensions". (Yehia and Asit 1985 pp. 2-3).

According to World Bank (1979), "the developing countries during (1970-1980) faced by three common problems with some differences in intensity in all LDCs. First LDCs are (obliged) forced to accept whatever international prices prevail for petroleum products, for oil importing developing countries, balance of payments problems, have become particularly acute. Important development initiatives can be constrained by the need to use a scarce foreign exchange to import fuel. The economic position of developing countries that are not oil exporter is steadily deteriorating with the continual rise in the price of oil and refined products, which constitute the main and in many cases the only energy supply for food, raw materials, manufactured goods, all have undermined the balance of payments accounts of oil importing LDCs. Moreover, trade deficits have increased debt level and debt servicing burdens and taxes". (W.B 1979).

"The second problem in these countries is the depletion of fuel wood in rural areas, these are equally severe, but less well known problem due to lack of reliable statistical evidence, most LDCs are faced by accelerating problems in the provision of their most important fuel wood source. The major reason behind such crisis is that wood fuel have been consumed at a faster rate than productive capacity on a sustainable basis. The result is that in many developing countries wood has ceased to be a renewable resource". (W.B. 1979). Serious consequences arise due to this crisis of deficiency in supply of these fuel. "According to Yehia and Asit (1985) while fuel wood availability and use vary from one country to another, one global trend is visible in most developing countries, the price of fuel wood has been rising at a faster rate than the rate of inflation during (1970s-1980s). Thus it is increasingly difficult for the rural poor to find the economic means to purchase fuel wood. The policy makers are generally aware of this, but the problem has not yet received the attention it deserves". (Yehia and Asit 1985).

The third problem according to World Bank (1979) is that "capital shortage in the LDCs economies have serious implications for their energy system. From a financial perspective, the shortage of human capital means that energy equipment is often poorly managed and inadequately maintained".(W.B.1979)

According to Yehia and Asit (1985), "acute scarcity of fuel wood in 1980s involved about 90 million rural people in developing countries, minimum energy need are not yet met, and energy consumption is below minimum levels. Deficit in 1980 involved 833 million rural people (population in this situation is amount to 146 million in Africa, mainly in Savanna areas in West, Central and South-East Africa). In North Africa and Middle East, 70 million rural people have fuel wood deficit, in Asia 550, in Latin America 82 million". (Yehia and Asit 1985 p. 2).

"Another problem is that alternative energy sources and technologies are costly and generally are financed by scarce foreign capital. Even where available the development of non renewable requires massive allocation of scarce capital, possible substitutes for high oil price (e.g. coal and natural gases) may be showed comparable price increases". (Phil O'keef, et al 1984 in (EEDA 1) chap.(2) P.9).

2.5 Summary and Conclusion :-

It has been evident that sustainable development consider as an innovative concept and represents a chance for the less developed countries to design their future development in a way that is considered to be sustainable. The pattern of present use (consumption) and production of energy threatens the objectives of sustainable development through its environmental degradation and natural resources exhaustion in both developed and developing countries. The picture is less clear before 1960s, but since 1970s, the environmental considerations of energy use become serious. This has been associated with the sudden energy crisis or oil crisis that reflects the importance of energy planning in economic development as it is considered a vital input for all economic activities. Energy crisis in the developing countries become acute and its reflection and implications on the process of economic development requires adequate and urgent actions.

CHAPTER THREE
MACROECONOMIC ANALYSIS OF ENERGY SECTOR IN THE SUDAN

Chapter Three

Macroeconomic Analysis of Energy Sector in the Sudan.

3.1.1 Introduction

The present chapter focuses on the structure of the energy sector in the Sudan i.e. energy capacity (energy supply) and energy demand. The identification of supply-demand pattern is important for the understanding of the nature, causes and the consequences (i.e. the economic implications) of energy crisis in the Sudan.

"The Sudan is the largest African country, however, the country potential energy resources are not fully utilized, this make few supplies of indigenous sources other than fuel wood, at current time. Commercial energy resources are limited to hydroelectricity, thermal power and the recent discoveries and exploitation of oil and gases".(UNDP. W.B 1983 p.10).

The present chapter begins with the importance of energy sources to the process of economic development, the sources of energy,section two dicusses the nature and the causes of energy crisis in the Sudan. Section three deals with energy resources and the supply-demand pattern during the period (1980-1995),using the available time series data, the section discusses the structure of energy sector in the Sudan.The fourth section identifies the sectoral consumption in the period (1980-1995), using the time series data, energy demand by types and sectors is analyzed.

The present chapter focuses on the major energy sources used in the Sudan these include biomass , electricity and petroleum products for their role in energy supply-demand balance.

3.1.2 The Importance of the Energy Sector :-

Like many other developing countries the Sudan has experienced an acute energy crisis since 1970s. The importance of the energy sector stems from the fact that, the economic performance of the major or key productive sectors in the Sudan's economy largely depends on the availability and the regular supply of energy.

"During the last two decades, the continuous shortage in energy supply and its impacts on productivity, capacity utilization and growth in different sectors of the economy resulted in poor economic performances. This supports the claim that Sudan's present economic crisis is partially attributed to crippling energy sources in the economy". (UNDP. W. B. 1983).

This is clearly observed at the sectoral level, for example "in the agricultural sector which is the leading productive sector in the Sudan's economy, inadequate and unreliable supply has a serious impacts on the production and distribution of crops, particularly in mechanized rain fed and pump irrigated fuel dependent sub-sectors, in this way output losses due to fuel shortage were higher. Moreover, the economic development of the industrial sector has also constrained by poor capacity and power shortage, inadequate and unreliable supplies have both resulted in higher production cost, lower capacity utilization and poor economic performance. On the other hand, the performance of the transport sector was affected by inadequate and unavailability of oil and oil products on which the sector is totally dependent.This created transportation bottlenecks, which in turn have constrained production and distribution in most sectors of the economy".(Energy Hand Book. 1991 chap.(2) p. 12). "Thus both consumers and producers in Sudan have suffered from such crisis, their welfare constrained by frequent power interruption, inefficient and unreliable public power supply.Moreover, an absolute scarcity of energy and unreliable supply limited economic growth rate (i.e. GDP growth rate),because inadequate energy supply causes reduction in planted and irrigated areas and limitation on industrial factories expansion".(C.de. Jong-Boon, 1990 pp. 272-273, UNDP.W.B. 1983, NEA, NEP pp. 1-12 1985).

The energy sector in the Sudan is characterized by inefficiency, low capacity utilization, major financial constraints and rapidly growing demand for energy. Total energy consumption increased through the period (1965-1995). According to the W.B. (UNDP) estimation in 1983/84 the per-capita of total energy consumption in 1983/84 was about 0.38 (TOE),[1] and according to them was, one of the lowest per-capita consumption in the world and even among the developing countries. According to table (3.1) per-capita total energy consumption decreased from 0.31(TOE) in 1973 to 0.252 (TOE) and .254 (TOE) in 1983 and 1985 respectively, but it increased to 0.266(TOE) and 0.29 (TOE) in 1990 and 1993 respectively, while the per-capita GDP* changed from 292 in 1983 to 268.64 and to 356.49 in 1985 and 1993 (see table 3.1), according to table (3.1) there is strong relationship between per-capita (GDP)and per-capita total consumption through the period (1973-1993). During the period (1980-1994) both total and commercial energy consumption have increased e.g. total energy consumption has increased from 4964373 (000)(TOE) in 1980 to 5622665 (000)(TOE), 6533221 (000)(TOE) and 7522107 (000)(TOE) in the years 1985, 1990 and 1994 respectively. Moreover, total commercial consumption has increased from 1295220 (000)(TOE) in 1980 to 1422520 (000)(TOE), 1784373 (000)(TOE) and 1846107 (000)(TOE) in the years 1985, 1990 and 1994 respectively .(table (3.1) and fig.(3-1.a) and (3-1.b)).On the other hand,

[1] TOE, used as a measure of energy consumption ,stands for "ton of oil equivalent" and it is defined as being equal to 10.2 kilocalories (kcal).
* GDP Per- Capita represents per- capita income.

during the period (1980-1994) both per-capita total energy consumption and commercial energy consumption were very low, per-capita commercial energy consumption slightly increased but never exceeded .1 (TOE), on the other side, per-capita total energy consumption also slightly increased and ranged between .2 (TOE) and .3 (TOE).(fig.(3-1.c) and (3-1.d)). Per-capita commercial energy consumption has increased during the same period from .060 (TOE) in 1983 to .064 (TOE) in 1985 to .069 (TOE) in 1990 and 1993 and to .072 (TOE) in 1994. During (1973-1993), in most cases there was a relative change or growth in total and per-capita total energy consumption, per-capita commercial energy consumption and per-capita GDP. According to table (3.2), total energy consumption increased from 1107.4 (000) (TOE) in 1964 to 4178.8 (000) (TOE), to 4964373 (000) (TOE) to 6865539 (000) (TOE), 7522107 (000) (TOE) and to 8461000 (000)(TOE) in the years 1970, 1980, 1990, 1994 and 1996 respectively. The growing demand was attributed to the requirements of economic development, this caused excess demand problems, because the continuous increase in the demand was not accompanied by adequate growth in the supply (generation capacity). All sources of energy in the Sudan suffer from this problem.

Like the other sectors in the economy, the energy sector suffers from inadequate finance to develop the sector. Despite the fact that total expenditures allocated for development purpose in all sectors and energy sector in particular increased during the period (1980-1995). During the period (1981/82-1994/95) total expenditures allocated to the energy sector has doubled and increased from 58,8 million Sudanese pounds in (1981/82) to 425,4 million Sudanese pounds in 1990/91 and 149,0 million Sudanese pound in (1994/95). The percentage has changed from 19.2% in (1981/82) to 23.1%, 16.9% and to 18.5% in the years 1986, 1988/89, and 1990 respectively, however, the percentage declined during 1990s to 16.25% and 11.62% in the years 1992 and 1994 respectively, (table (3.6) and fig.(3-6.a)). (The Economic survey (1990-1995)). Recently the sector received highest priority in total expenditures, it occupies the second place (priority) after the agricultural sector. The total average expenditures on all sectors through the period (1980/81) - (1985/86) was estimated to be 29. 2%, 16%, 13%, 12.7%, 8.4% and 6.6%. For the agricultural, transportation and communication, regional or rural development sectors, energy and mining and industrial sectors respectively. (The Economic survey (1990-1995)).

After (1987/88) the energy sector occupied the second priority in total expenditures, on average the sector receive 17.7% of total expenditures during the period (1987/88-1991/92) compared to 27.2% of the total expenditures for agricultural sector during the same period. In 1990 because of merging water sector with energy and mining the sector have a highest share of total expenditures accounted for 18.5%, rather than 13.6% of total expenditures in (1989/90). According to table (3.6) total expenditures on energy sector increased and doubled during the period (1981-1994) the ratio of energy sector expenditures to total sectoral expenditures ranged between 19.2% and 11.62%. According to fig.(3-6.b) the average ratio of expenditures on energy sector to total development expenditures during the period (1981-1994) was about 15.44%, while the other sectors in the economy on average received about 84.56% of the total development expenditures during the same period. The sector occupied and received the second highest percentage of total expenditures, although the sector have the lowest percentage share on total GDP and on average its contribution to total GDP was very low and marginal and did not exceed 2.5%, (e.g. the electricity and water sector contribution on GDP was ranged between 1% and 2.3% during the period (1980-1991)). (The Economic Survey (1980-1995)).

As in many other developing countries the energy sector in Sudan suffers from inefficiency, a considerable amount of losses occurred in the three types of energy used in the country. According to table (3.4 and fig. (3-4.a) and (3-4.b)) in 1981 the total supply was 9.7 million (TOE) and the total amount reached end use estimated about 6.1 million (TOE), i.e losses estimated to be 3.6 million (TOE). In (1986/87) total supply was 12 million (TOE) out of this only 7.7 million(TOE) or 64% of total supply reached end use and about 36% was lost.Charcoal conversion accounted for 90% of total conversion losses. In (1987/88) the total supply was 10 million (TOE) and total amount reached end use was about 6.1 million (TOE), there was about 4 million (TOE) or about 40% losses during the process of conversion, transmission and distribution, in the biomass sector losses occurred in energy was 44% of wood supply lost in the process of converting wood into charcoal. In (1989/90) the total supply was more than 10 million (TOE), losses accounted for more than 4 million (TOE) i.e. 40% of total supply. In (1992/93) the total supply was 11.677 million (TOE), total consumption was 6.653 million (TOE) i.e. about 57% of total supply. Losses estimated to be 5.024 million (TOE) i.e. (about 43%) of total supply. In (1993/94) the total supply has increased to 11.139 million (TOE), final consumption was 7.381 million (TOE) about 68% of total supply and losses estimated to be (4.3%), 3.758 million (TOE). The efficiency in the sector was only about 61%, 4 million (TOE) out of 6 million (TOE) were lost in the biomass sector, in electricity sector losses were estimated to be 1% in hydro and more than 70%. In thermal, petroleum losses in refinery process was estimated to be 5% of total crude oil used. Moreover 2% of total petrol supply lost in the process of distribution and transportation (Energy Hand Book 1987, 1990 and 1991 and Ministry of Energy and Mining Statistics (1992/93 - 1993/94)).

3.1.3 Energy Supply (by Sources):

(a) Biomass:

Currently, the Sudan has few exploitable energy sources, the major energy sources which are used in Sudan are mainly composed of traditional (non commercial) type, this includes biomass which is sometimes classified as fire wood, charcoal and agricultural residues. These on average accounted for 82% of total energy supply, and commercial types which include petroleum and electricity (both hydro and thermal), these on average accounted for 18% of total energy supply, about 94.4% of commercial energy were imported in form of petrol, i.e. the country must import 95% of its commercial energy. The country is highly dependent on traditional sources because of abundancy of forests as major sources of this type of energy.The traditional biomass is a major indigenous source and expected to continues to be the major one in the short and medium term.Electricity is the second indigenous source of energy.(UNDP. W.B 1983).During (1983-1993),the biomass sector on average accounted for about 81.5% of total demand and accounted for about 85.1% of total supply.(fig.(3-4.c), (3-4.d), (3-4.e) and (3-.4.f)).

(b) Electricity:-

"Domestic commercial energy resources are limited to electricity and the recent discoveries and exploitation of oil and gas in the Southern - Western regions and other areas in the country,hydroelectric resources are more modest than would be expected due to the low river gradient. Electricity generation capacity either from hydroelectric or thermal have the lowest share in the total supply on average it accounted for only 1% of total supply during the period (1980-1995) and represented about 4.5% of total commercial energy in the country during the same period major electric generation from Blue Nile Grid and Eastern Grid. In 1983, Blue Nile Grid serve 85% of customers receiving public supply in the country. Between (1975-1981) growth rate in electricity generation is estimated to be 8.6%, 9.5% and 3.7% in the National Electricity Corporation, Blue Nile Grid and Isolated system respectively. In 1981 National Electricity Corporation generation was 965 (GWH)[2] provided about 65% of Sudan's total electricity consumption, the sector was not working at full capacity due to age, lack of spare parts and other constraints. The annual growth rate of private self generation was estimated to be 70% since 1978, this represents 50 percent of national electricity corporation generation capacity in 1983" (UNDP.W.B. 1983). During the period (1985-1994) the total generation increased from 1266 (GWH) in 1985 to 1858.73 (GWH) in 1994 and the total consumption has changed from 1173.19(GWH) in 1985 to 2178(GWH) in 1994. (see table 3.5 and fig. (3-5.c), (3-5.d) and (3-5.e)). Between (1993/94 - 1994/95) total generation capacity increased by about 6.7% per year while the rate of increase in consumption by different sectors according to fig. (3-5.f), is estimated to be about 6.6%, 10.6%, 5.6%, and 6.3% for the household, agricultural, industrial and other sectors respectively, these sectors during (1985-1994) on average consumed about 57%, 12.4%, 21.6% and 9%, respectively (fig. 3-5.b). During the period (1983 - 1993) electricity sector on average accounted for about 1.2% of total energy demand and about 2% of total energy supply.(fig.(3-4.c), (3-4.d), (3-4.e) and (3-.4.f)).

[2] GWH, KWH and MWH used as a measurement unit of electricity consumption and generation.

(c) Petroleum :-

Petroleum is the major commercial energy resource used in the country, mostly imported on average it accounts for about 17% of total supply. During the period (1970-1996), the total consumption increased from 640.3 (000) (TOE) in (1970) to 1240984 (000) (TOE) in 1980 and to 1584472 (000) (TOE) in 1990 and to 1654000 (000) (TOE) in 1996. This increase is attributed to the process of economic development of the major consuming sectors (mainly the agricultural and industrial sectors) and the expansion in road and transportation sectors.(Table (3.2)). During (1983-1993) on average the sector accounted for about 17.3% of total demand and about 12.9% of total supply.(fig.(3-4.c), (3-4.d), (3-4.e) and (3-.4.f)).

(d) Solar energy :-

"Due to its geographical position, the country receives high solar isolation which could be a valuable source of energy to cover part of the current growth in demand, when appropriate technologies developed. Solar energy in Sudan could be used for the following purposes like (a) water heating for low temperature commercial and industrial application. (b) Photovaltaic cells for remote, small scale applications. However, according to (NEA) and foreign experts studies only item (a) could have a substantial utilization and market potential in the country. According to (NEA) solar water heating would have an internal rate of return of 8.8 when substituted for fuel oil". (UNDP. W.B. Report 1983).

(e) Winds energy :-

The wind energy potential generally increases from South to North as well as the wind is favourable in the northern part of Sudan and may be expected to contribute marginally to cover parts of Sudan's energy needs.In 1950s about 250 wind mills of American design were installed in the Gezira province for pumping, drinking water for dispersed small communities, but they were replaced by diesel and electric driven pumps because their operating and maintenance costs were high, spare parts were lacking, and design was inadequate for Sudan's conditions. (UNDP.W.B. 1983).

(f) Molasses energy :-

"Molasses used as a substitute for gasoline, in 1980, a study by Tate and Lyle Technical Services (TLTS) estimated molasses availability in the public sector at full capacity as 43.800, 40.800, 26.400, 25.600 and 130.000 mtpa* in Sennar, Assalaya, New Halfa, Guneid and Kenana. The potential for ethanol production for this total quantities of molasses estimated to be about 45,000 mtpa". (UNDP. W.B. 1983).

(g) Bagass Energy :-

"In most world countries, Bagass is extensively used as a source of primary energy after meeting the needs of the cane sugar industry. According to (UNDP.W.B. 1983), in Sudan the ratio of fibre to cane was estimated to be 18% which is higher than in most countries, so that potentially large quantity of bagass is available, but due to some difficulties, sugar industry is a net energy consumer i.e. depend on either electricity or petrol rather than using bagass. These difficulties are (1) The factories are poorly managed and operated intermittently (2) cane supplies are inadequate or unreliable". (UNDP.W.B. 1983).

3.2 Sudanese Energy Crisis :-

According to NEA.(NEP) (1985) "Sudanese energy crisis could be attributed to two main problems. First there is a lack of foreign exchange for the imports of petrol which currently mostly used for transport and increasingly also for electricity generation. The result is a vicious circle,

* MTPA used as a measurement unit of Molasses energy.

lack of hard currency with which to buy essential energy inputs, e.g. for agriculture lead to decline in exports earnings which lead to further shortage of hard currency. The second problem is that forests will disappear from the Northern and Central provinces by the year 2000. These supply wood and charcoal on average accounts for 80% of final energy consumption, most of this is used in household cooking and smaller part in industries such as Khartoum Brick Making and bakeries. This means that Sudan will face an acute shortage in the first and most important source of energy. There is of course a link between the two problems. Lack of imported fuel lead to increase in the use of indigenous biomass as substitute for imported oil which cost the country hard currency. But the substitution of imported petrol by indigenous biomass caused diminishing or shrinking in the stock of forests, which have a serious environmental impacts". (NEA/NEP. 1985 and C. de. Jong-Boon, 1990 pp. 253-254).

"The highest dependence on imported oil as a major commercial energy source has aggravated the balance of payments disequilibria through directing most exports revenues to finance or cover oil imports bill which is subject to fluctuation according to the world market price i.e. inflation in world market. (NEA/NEP, 1985). During 1970s, the main causes of energy crisis was the sudden dramatic escalation in oil prices with the second jump in 1980s. High prices not only make it more difficult to buy oil, but also means that scarce hard currency has to be diverted from other development purposes and therefore slowing economic growth". (NEA/NEP,1985) and C.de. Jong-Boon, 1990 p.278).

"These shortages of foreign exchange in turn drastically reduced the country's capacity both to buy oil and to make important needed investment in expanding electricity system". (NEA/NEP, 1985) and C.de.

Jong-Boon, 1990 p.278). "Inadequate finance to construct energy projects, lead to delay in implementation and execution and therefore increased the demand-supply gap, on the other hand, the migration of well trained and highly qualified workers to oil producing Arab countries make it difficult to deal with and to treat the crisis. In addition to governmental policies which failed to act and react with the crisis has been done at the expense of future long run plan, added to this the lack of a comprehensive and a complete over view or strategy to deal with the different energy sources used in Sudan. Moreover, as in many other developing countries, the energy sector in Sudan was subsidized this trends underestimated the real cost, encouraged consumption and discouraged regulation". (NEA/NEP 1985, the Four Year Programme for Development Reform and Salvation 1987/88 - 1990/1991 pp. 3-4).

Factors like inefficient uses of energy and increase in demand and failure of efforts to discourage extravagant consumption, in adequate finance and insufficient investment are common in all sectors.

Regarding petroleum sector,four factors interacts to create problems in this sector. "First there is insufficient investment in this sector due to foreign exchange shortages which causes inadequate and unreliable supplies. Second inefficient use of existing system attributed to the unfavourable terms on which petroleum is purchased, poorly utilized system because the supply varies with foreign exchange availability. Third there is a continuous increase in total demand to satisfy economic growth objectives, due to increase in the demand in agricultural, industrial, transportation and consumer good sectors. Fourth consumption encouraged due to many reasons such as subsidization of prices i.e. product priced below the economic cost, unrestricted imports of energy, inefficient system, expansion of thermal power not hydro, unreliability of river and road has forced shifting to trucking and to private transportation over the public one, and high dependence on private electric machines increased pressures on petrol and balance of payments". (C. de. Jong-Boon, 1990 p. 279).

On the other side, the electricity sector is faced by similar problems. "First insufficient investment due to inadequate investment in generating capacity particularly hydro and inadequate attention given to electricity investment in allocation of scarce capital. Second inefficient use of existing system attributed to inadequate maintenance, lack of spare parts, large losses, delay in implementation of power projects, depletion of hydro storage capacity, man power brain drain, wide animal and seasonal variations in hydroability. Third, the growing demand attributed to increases in demand by agricultural, industrial and household sectors and increases urbanization and population growth, fourth consumption encouraged attributed to low (underestimated) prices and subsidy, unallocated, unbilled consumption, uncontrolled demand and growth without priorities". (C. de. Jong-Boon, 1990 p.280).

Concerning the biomass sector (fuel wood and charcoal), "the problem of insufficient investment was attributed to royalties for trees and forests, inadequate for replacement, second insufficient use of existing system due to many factors such as inefficient conversion and end use of technologies, lack of effective forestry land use management at national or regional levels. Third the increase in demand attributed to population growth and urbanization which caused higher demand for charcoal. Fourth consumption encouraged due to lack of alternative and the substitutes with lowest price and cost". (C. de. Jong-Boon, 1990 p. 281).

3.3 Energy Resources and Supply-Demand Pattern (1980-1995)

As in many African countries, the overall supply of energy in Sudan is characterized by the dominance of traditional biomass fuels i.e. fuel wood and charcoal. During the period (1983-1993) the biomass sector according to fig. (3-4.c and 3-4.d) on average accounted for 81.5% of total energy consumption in the country the average supply was about 85.1%. On the other side, the household sector considered to be the dominant consuming sector for overall energy supply. During the period (1983-1993) on average consumed about 76.1% of total sectoral consumption (fig. 3-7.B). This reflects the poor performance of the energy sector in Sudan, compared with the other developing countries.

There are some evidences that economic development positively correlated to the increase in commercial energy consumption. On the other hand, the structure of demand for energy types is also considered to be an indicators for development. As the percentage consumption of the productive sectors (agriculture, industry, and transport) increases and those of the household (domestic sector) decline, this is serve economic development objectives. Consequently, the highest percentage of consumption by the domestic household sector in most developing countries and Sudan indicates the poor performance (weakness and underdevelopment) of the economy's productive sector.

During the period (1964/65 - 1994/1995) there was a considerable increase in energy consumption. Total consumption by different sectors increased from 1107.4 (000) (TOE) in (1964/65) to 4964373 (000) (TOE), 6533221 (000) (TOE), 7522107 (000) (TOE) in 1980/81, 1989/90 and 1994/95 respectively. According to table (3.2) and fig. (3-2) the amount of total consumption measured in thousand total oil equivalent (TOE), has doubled during the same period, due to the process of economic development. The total consumption in 1996 was estimated to be 8461000 (000) (TOE), of which biomass accounted for 76.9%, electricity accounted for 3.4% and petroleum products accounted for 19.5% of total energy consumption in Sudan. According to fig.(3-2.c) and (3-2.d),during the period (1980-1989),average consumption of biomass, electricity and petrol was about 75.4%, 1.5% and 23.1% respectively compared with average consumption of about 75.7%, 3.9% and 20.4% respectively during the period (1990-1996).The total consumption of biomass, electricity and petrol have changed and increased during the period (1980-1989) and the period (1990-1996).(fig.(3-2.a)and fig.(3-2.b))

According to table (3-3) and fig.(3-3.a)the forecasts of total energy consumption in Sudan for the period (1996-2010) reveal that the total consumption by the three sources of energy will increase from 8635 (000)(TOE) in 1998 to 9419 (000) (TOE), 11397 (000) (TOE) and 13941 (000) (TOE) in the years 2000, 2005 and 2010 respectively.

The share of electricity is expected to increase to 5.3%, 6.8% and 8.3% of total expected consumption in the years 2000, 2005 and 2010 respectively, petroleum consumption share is expected to increase to 22.5%, 25.5% and 29.3% of total expected consumption in the years 2000, 2005 and 2010 respectively. These forecasts for petroleum could be attributed to a continuous exploitation of indigenous (Sudanese) petroleum sources. These forecasts reveal that the biomass share will witness a steady decline during the same period, the share estimated to decline to 69.91%, 67.7% and 62.3% of total consumption in the years 2000, 2005 and 2010 respectively. This projection is due to shrinking forests and environmental awareness and due to increase in prices of fuel wood. On average the biomass, electricity and petrol sectors expected to account for 68.7%, 6.3% and 25% of total energy consumption respectively during the period (1996-2010).(fig.(3-3.b)).

During the period (1980-1993), biomass consumption by different sectors increased from 3669154 (000) (TOE) in (1980/81) to 5011703 (000) (TOE) in (1989/90) and to 5522000 (000) (TOE) in (1993/94). Electricity consumption increased from 54236 (000) TOE in (1980/81) to 102400 (000) (TOE) in (1989/90) (i.e. the amount was doubled) and to 318067.3 (000) (TOE) in (1993/94). Total petroleum consumption increased from 1240984 (000) (TOE) in (1980/81) to 1419118 (000) (TOE) in (1989/90) and to 1390705 (000) (TOE) in (1993/94).(Table(3.2) and fig.(3-2.a)and (3-2.b))

Table (3.4) shows energy supply-demand balance during the period (1981/82- 1993/94). Total supply has increased during this period from 9.7 million (TOE) in (1981/82) to 10 million (TOE), more than 10 million (TOE), 11.677 million (TOE) and 11.139 million (TOE) in the years (1987), (1989/90) (1992/93) and (1993/94) respectively. On balance the consumption by different sectors accounted for 6.1 million (TOE) in the years 1981/1982 and 1987, less than 6 million (TOE), 6.653 million (TOE) and 7.381 million (TOE) in the year (1989/90), (1992/93) and (1993/94) respectively. The gap between supply and final consumption represents losses which on average account for 4 million (TOE) i.e. 40% of total energy supply were lost in the form or process of conversion, transmission and distribution, the highest percentage of losses indicates lowest technical efficiency, losses in 1993/94 was estimated to be 3.758 million (TOE) compared with 5.024 million (TOE) i.e. about 43% in (1992/93).

According to table (3.4) total energy supply and demand by type during the same period varies considerably. Traditional biomass fuel wood and charcoal dominate the supply and on average accounted for 85.6% 82% in 1981 and 1983 respectively. In (1981/82) total energy supply was 9.7 million, biomass accounted for 85.6%, of total energy supply. The percentages share of biomass was estimated to be about 82%, 84%, 82%, 87% and 86% in the years 1983, 1987, 1989, 1992 and 1993 respectively. The percentage of total consumption during the same period was estimated to be 82% of total consumption in 1981 and 1983 and accounted for 81.8% and 81% in 1987 and 1989/90 respectively. The decline in total supply was due to shrinking in the stock of forests. On the other hand, the decline in consumption was attributed to increasing awareness about the serious consequences (i.e. environmental consequences) resulted from such consumption pattern in addition the scarcity of fuel wood and charcoal has raised their prices.

The rest oftotal supply is covered by commercial sources, petrol accounted for 17% of total energy supply and hydroelectricity accounted for 1% of total energy supply, hydroelectricity accounted for 5.5% of total commercial energy supply and petroleum mostly imported accounted for 94.5% of total commercial energy supply in Sudan.This indicates the highest dependence on imported energy.The agricultural industrial, transportation and household sectors are the major consuming sectors.

Regarding petroleum, its percentage contribution in total energy supply was estimated to be 14%, 12.5%, 14% , 13%, 12%, 12% and 13% in the years 1980/81, 1981/82, 1983, 1987, 1989/90, 1992 and 1993/94 respectively. On the other hand, the total oil consumption accounted for 18%, 17%, 17.5%, 17.2% and 17% in the years 1981/82 and 1983/84, 1984/85, 1987 and 1989 respectively, "Between 1980/81 and 1989/90 oil consumption has increased by 73%". (The Four Years Programme for Development, Reform and Salvation (1987/88) - (1990/1991) p. 9), "which attributed to the rapid expansion in road construction which encouraged the usage of passengers vehicle and private cars. Moreover the expansion of generation of thermal electricity has increased the consumption of petroleum products. According to NEA, the gap between the demand and supply was estimated to be 25% in 1983/84, during the period (1980-1990) the gap is estimated to range between 15% and 20%" .(Four Years Programme for Development, Reform & Salvation (1987/88-1990/91 p.5). The decline in petroleum importation was attributed to increases in oil prices in the world market, which is subject to a continuous inflation, and due to their negative effects on the balance of trade and balance of payments.

Electricity (hydro or thermal) has the lowest share in total energy supply, it accounted for only 1%, 1.9%, 4%, 3%, 1%, 1% and 1% of total energy supply in the years 1980, 1981, 1983, 1987, 1989, 1992 and 1993 respectively. There was an increase in thermal generation, its share in total electricity supply increased during the period (1980-1993), namely its share was estimated to be 20%, 33%, 40% and 42% of total electricity supply in 1980, 1989/90, 1986/87 and 1993/94 respectively, hydroelectricity accounted for 80%, 67%, 60% and 58% during the same period; total hydroelectricity consumption during the same period (1980-1990) has increased, it accounted for 1%, 1%, 1.1%, 1% and 2.0% in 1981, 1983, 1984, 1987 and (1989/90) respectively. "The demand-supply gap was estimated by 25% in 1983/84. Total electricity consumption increased in 1986/87 by 6.3 times that of 1964/65 due to urbanization and development and expansion in the industrial sector. In 1981 per-capita electricity consumption was estimated to be 60 (KWH), however access to electricity supply is limited only to about 8% of the population". (UNDP.W.B.1983). Total electricity generation has increased during the period (1985-1994). In 1994/95 total electricity generation was about 1858.73 (GWH) with a percentage increase of 6.7% compared with the year 1993/94. Total electricity generation and consumption have increased during the period (1980-1994) according to table (3.8) and fig.(3-8.a), (3-8.b) and (3-8.d) total generation increased from 787.34 (GWH) to 1266 (GWH) 1855.83 (GWH) in the years 1980, 1985 and 1994 respectively and total consumption increased from 630.65 (GWH) in 1980 to 1173.19(GWH) and 2178 (GWH) in the years 1985 and 1994 respectively. Per-capita (production) generation increased from 44.714, (KWH) in 1980 to 57.285 (KWH) and 72.621 (KWH) in the years 1985 and 1994 respectively, on the other hand, per-capita consumption has increased from 35.366 in 1980 to 53.086 and 85.095 in the years 1985, 1990, 1994 respectively (table 3.8) and figure (3-8.c). Both total and per-capita consumption and production (generation) have increased during the period (1980-1994). During 1980s per-capita generation exceeded per-capita consumption because total production or generation exceeded total consumption. This represent the gap between demand and supply, however, during 1990s per-capita consumption exceeded per-capita generation because total consumption exceeded total production or generation. The household sector is the dominant consuming sector, e.g. during the period (1985-1994) the household sector accounted for 57% of total electricity consumption household consumption has increased from 738.62 in 1985 to 728 and 1250 in the years 1990 and 1994 respectively. Agricultural sector accounted for 12.4% of total electricity consumption during (1985-1994), the consumption increased from 23.38 (GWH) in 1985 to 195 (GWH) and 400 (GWH) in the years 1990 and 1994 respectively. Commercial and public sectors accounted for 9% of total electricity consumption during (1985-1994), the consumption of these sectors has increased from 111.03 (GWH) in 1985 to 133 (GWH) and 176 (GWH) in the years 1990 and 1994 respectively. Commercial sector consumption increased from 44 (GWH) in 1990 to 86 (GWH) in 1995, while services (public) sector consumption has increased from 89 (GWH) in 1990 to 103 (GWH) in 1995. The industrial sector accounted for 21.6% of total electricity consumption during (1985-1994), industrial sector consumption has increased from 300.16 (GWH) in 1985 to 184 (GWH) and 352 (GWH) in the years 1990 and 1994 respectively. (table (3.5) and fig.(3-5.a) and (3-5.b)).

3.4 The Sectoral Consumption of Energy Resources (1980-1993) :-

The energy sector is considered the vehicle or the engine on which the development of the productive sectors of each economy depends. The pattern of sectoral consumption of energy sector reflects or indicates the degree of development. In Sudan and in most developing countries the domestic household (or residential) sector is the dominant consuming sector, while the agricultural sector the leading productive sector in the economy, has the lowest share of energy consumption compared with the other sectors according to fig. (3-7.a) and (3-7.b) the average sectoral consumption during the period (1980-1993) was about 76.1%, 10%, 7.2%, 3% and 3.6% for the household, transport, industrial, agricultural and public service sectors respectively. This reflects or indicates the poor performance and a weakness and underdevelopment of Sudanese economy. Table (3.7) explains the sectoral energy consumption during the period (1978/79-1993), it is observed that, the percentage share of the agricultural commercial, public and services sectors and industrial sectors declined, while the percentage share of the domestic (household or residential) sector has increased during the period (1978-1993).

Regarding the agricultural sector, the percentage declined from 3.6% in 1978/79 to 3% in the years 1982, 1992 and 1993, despite the fact that the sector has the largest percentage share (35%-40%) of total GDP. The sector basically depends on petroleum as a major source of energy. In 1983 the sector has consumed 3% of total petroleum supply and 11% of total electricity supply. The percentage consumption of the sector declined to 2.7% of total energy supply in 1984 the percentage increased to 3.5% in 1987. The percentage declined to 3% in 1989/90, 1992/93 and 1993/94. Of this percentage in 1989, 98% was in form of petroleum products which is used mainly for irrigated and mechanized process, water lifting and agricultural operations. The sector mainly depends on or uses gas oil, furnace and diesel. The sector used only 3% of total biomass consumption in 1980, 1989 and 1990. The consumption of electricity in the agricultural sector declined from 11% in 1980 and 1983 to 3% in 1989 and 1990 of total sectoral electricity consumption. The sector depends mainly on commercial energy (electricity and petroleum), these make the farmers vulnerable to unreliable or irregular supply, which are affected by the availability of foreign exchange, this constrained the performance of the agricultural sector and the overall economy in Sudan.

The industrial sector is the second largest productive sector in the economy, the sector depends on the three types of energy sources. The percentage consumption of this sector was 8% of total energy consumed in 1982 and 1983. In 1983 biomass, electricity and petroleum accounted for 20%, 8% and 45% of total energy consumed in this sector respectively. In 1984 the percentage of total consumption by the sector has declined to 4.5% of total energy consumption by all sectors in the economy. Biomass, petroleum and electricity accounted for 47%, 45% and 8% of total consumption in this sector respectively. In 1987 industrial sector consumption has doubled and estimated to be 10% of total energy consumption and the biomass accounted for 50% of total supply in the sector in 1987. In 1989/90 the sector consumed 13.7% of total petroleum consumption in the economy. The industrial sector total energy consumption, in 1989/90 was estimated to be less than 7% of total energy consumption by all sectors, biomass accounted for 44%, petroleum accounted for 57% and less than 8% was the share of electricity in total consumption in 1989/90 in industrial sector. In 1989/90 the sector consumed 30% of total sectoral electricity consumption in the economy, compared with 36% in 1980. The total energy consumption in the industrial sector was declined to 6% of total energy consumed in the economy 1992/93, but it has increased to 7% in 1993/94. The sector depends mainly on petroleum and electricity, e.g. for big industries schemes the sector uses gas oil, diesel and furnace but the traditional small scale sector uses biomass, biomass and agricultural residues in 1993/94 accounted for 54% of total small scale traditional industries consumption.

The transport sector total energy consumption has declined from 11% in 1981 to 9% in 1982 and 1983,the figure increased to 10.9% in 1984,the sector basically depends on petroleum products like furnace, diesel, gasoil, benzine, avagas and Jet-AI,it is the largest consuming sector of petroleum products in the economy.In 1980 the sector consumed 57% of total petroleum products consumed in the Sudan, this is increased to 60% and 64% in 1989 and 1993 respectively. The total energy consumption by the sector was about 10% in 1987,1989 and 1993 and was about 11% in 1992.On average the transport sector consumes about 50% of total petroleum products consumption in the economy. In 1989/90 and 1993/94, the transparent sector consumed 10% of total sectoral energy consumption.The transport sector has consumed about 57% of total petroleum products consumed by all sectors in the economy in 1980, compared with 60% and 64% in 1989/90 and 1993/94 respectively.According to Energy Hand Books, Petroleum products consumption increased in the transport sector due to the expansion in the construction of paved roads to connect cities,due to urbanization and shifting from the other modes of transportation.There is anticipation for further increases in the consumption of oil by this sector due to discoveries and the beginning of commercial production in domestic Sudanese petroleum products,if the process of discoveries and exploitation proceed and succeeded,petroleum consumption will increase and the demand for it will shift in order to substitute other sources.

The other sectors included in public-governmental and services sectors and sometimes commercial sector, the consumption of these sectors declined from 4.5% in 1978/1979 to 4% in 1982 and 1983. In 1983 these sector consumed 4% of total energy consumption by all sectors in the economy, the share of petroleum ,electricity and biomass in these sectors was about 4%, 6% and 27% respectively. In 1984 the percentage consumption of these sectors declined to 3.8% of total energy consumption, and these sectors consumed 4.27% of total biomass consumed in Sudan, 3.96% of total petroleum products and 6.45% of total electricity consumed in Sudan. In 1987 the percentage consumption in these sectors declined to 3% of total sectoral energy consumption in the economy, biomass accounted for 80% of total energy supply in these sectors. The percentage consumption of these sectors increased from 3% of total sectoral energy consumed in the economy in 1987/1988 , 1989/1990 and 1992/1993 to 4% of total sectoral energy consumption in the economy in 1993/1994. In 1989/1990 these sectors consumed 10% of total electricity consumption by all sectors in the economy. In 1993, the share of biomass, electricity and petroleum products in these sectors was about 9.1%, 5% and 4% respectively.

The domestic-residential (household) sector is the biggest energy consuming sector in the Sudan. The household sector consumption has increased from 41.3% in 1978/1979 to 77. 8% in 1981 , 75% of total sectoral energy consumption in the economy, in 1982 and 1983 and 77.2% in 1984. The household sector has consumed about 72%, in 1987 and more than 77% of total energy consumption in the economy in 1989, 1992/1993 and 1993/1994 respectively.Most of this energy was in the form of traditional biomass fire wood and charcoal. On average the sector consumed more than 90% of total biomass consumed in the economy, 20% of total electricity and about 3% of total petroleum products consumed in the economy. The sector mainly uses kerosene, liquid petroleum gas (L.P.G) and gas oil. In 1983 the sector consumed 75% of total sectoral energy consumed in the economy. Biomass accounted for 98% of total supply in this sector. The sector consumed 44% of total commercial energy mainly electricity. In 1984 the percentage consumption has increased to 77.2% of total energy consumption in the economy, the share of biomass and commercial energy in total supply in this sector was about 77.5% and 93% respectively. During the period (1980-1993), the sector was the dominant consuming sector.During (1989/90 - 1993/94) it accounted for more than 77% of total sectoral energy consumption in the economy. In 1989/90 the share of biomass and electricity sectors was about 93% and 60% of total supply in this sector respectively. The household sector has consumed about 60% of total sectoral electricity consumption in 1989/90 compared with 39% in 1980. Petroleum consumption in this sector declined in 1989/90 relative to

1980. In 1990 the share of biomass and electricity sectors was about 95% and 66% respectively of total supply in this sector. In 1993 the share of biomass and electricity sectors was about 93% and 51% respectively of total supply in this sector.

3.5 Conclusion :-

The present chapter explored the structure of energy in the Sudan. The analysis revealed that, the energy crisis in the Sudan was due to many factors and all sectors suffered from such crisis. Attempt must be made to alleviate such crisis. Problems of unavailability, inefficiency and inadequate finance must be treated as soon as possible. Per-capita energy consumption was very low in the Sudan compared with the other developing countries, but relatively growing over time. During the period (1980-1994) per-capita total energy, per-capita commercial energy and per-capita electricity consumption showed a relative change. The household sector is the major energy consuming sector and on average has consumed about 76.1% of total energy consumption during the period (1980-1993) this indicates or implies the weakness and under development or poor performances of Sudan's economy.

CHAPTER FOUR
STATISTICAL ANALYSIS AND ESTIMATION OF ENERGY DEMAND FUNCTION IN THE SUDAN

Chapter Four

Statistical Analysis and Estimation of Energy Demand Function in The Sudan

4.1.1 Introduction

For a developing country like Sudan, the statistical analysis and estimation of energy-demand function is important and useful for the explanation and understanding of the pattern of energy demand in the country, the nature and determinants of energy crisis the development and implications of such crisis.

Recently, the demand for energy in the developed and less developing countries continues to increase rapidly. Since the mid of 1970s, due to growing concern about the environmental issues associated with different types of energy use, scarcity of energy and higher prices being paid to it , energy policy and planning are becoming extremely important. Nowadays , attention in many developing countries is critically and extremely devoted to establish a comprehensive energy conservation programmes, in this respect an assessment and estimation of energy demand at regional, sectoral and national levels(i.e. at micro and macro levels) are becoming extremely important in the context of national regional and global development.

The present chapter begins with the identification of the model of estimation i.e. it defines the model, gives justification for using such model. Based on the available time series data for the period (1980-1989), and (1980-1993), an attempt is made to estimate the sectoral and the aggregate demand equations for the basic three sources or types of energy used or consumed in the Sudan. Using the conventional (normal) demand function which depends on the prices of energy types and income, moreover, the price of substitutes, taste and habits are assumed constant. for simplicity, the present study is based on Logarithm (natural Logarithm) demand functions that depend on energy prices and income factors, the rest factors are considered to be constant. Under the assumption that the prices of energy types are exogenously determined, the first part of the present chapter, used the multiple ordinary least squares technique or model to estimate the demand for (sectoral and total) biomass, electricity and petroleum products and total energy demand function using available sectoral disaggregated data.

Considering the fact that petroleum products is an imported good, the second part of this chapter examines the claim or hypothesis that petrol imports price is endogenously determined or constrained by the availability of foreign exchange receipts. This assumption is verified using time series data for the period (1980-1993). The second part used a complete imports model which contains two independent structural equations simultaneous imports supply-demand equation model imports supply curve assumed to be inelastic with respect to price, and a normal downward sloping demand curve. To estimate demand function the two-stage least squares model is used.

4.1.2 The Demand Model :-

This section of the present chapter describes the formulation or the process by which the demand model is used to estimate the energy demand equations.

The model has been derived by using the time series data covering the period (1980-1993)[3]. The data base of the Sudan's demand model

[3] The present study benefited from the formula and analysis presented in "An Energy Demand Model For Sudan", a study prepared in the Institute of Environment Development and Quantitative Economic Research of Johann Wolfgan Goethe-University, under the supervision of Professor Gerhard Gehrig Frankfurt (1989).

contains annual consumption of the major products in each of the five consuming sectors in Sudan. It is necessary to consider consumption on sectoral basis due to the fact that each sector may respond differently to varying prices and technological changes. The major five consuming sectors are residential (domestic or household), agricultural, industrial, transportation, commercial, public services and trade sectors and other sectors. Most sectors have a significant demands only for certain types of energy, therefore consumption data for less significant types are neglected.

The model used the historical available data on prices and tariff to estimate the demand for biomass and electricity. Regarding petroleum products, due to variation in prices of petroleum products throughout the country, a random sample of eight towns is used to estimate the weight average price for the major six products used in the Sudan.[4] In addition to this, the model required the use of data about GDP (real) and the share of energy consuming sector in GDP as a factor of (or as a proxy for) income.

4.1.3 Energy Demand Modle Formulation :-

The structural equation of energy demand are based on time series data.[5] The functions were estimated on time series data for specific period of time (1980-1989) and (1980-1993) in order to make use of all available information. The method of ordinary least squares has been applied. Most

[4] The sample includes Khartoum, Port Sudan, Wad Medani, Kassala, Atbara, Elobid, Nyala and Juba. The sample used Juba prices when available (only for the period of 1980-1983), due to unavailability of information due to civil war and instability in Southern regions). The sample reduced to seven towns excluding Juba due to non availability of date after 1983 up to 1993.

[5] These data were obtained from Ministry of Energy and Mining publications. E.g. Energy Hand Books. Energy statistical units including data from (G.P.C.) General petroleum corporation and NEC -National-Electricity-Corporation, in addition to Bank of Sudan Annual Reports and the Economic survey.

prices of the model are exogenous, which means they should be given when performing model application.

4.1.4 The Structure of Sudanese Energy Demand Model :-

Energy demand in Sudan is estimated by econometric technique which involves, the application of multiple techniques to such data as energy prices and per-capita income or the sectoral contribution in GDP. In the second part for the solution of the simultaneous equation model, additional factors were added to verify the assumption of endogenous price of petrol as an imported good these factors include petroleum products imports volume the lagged imports volume, the lagged value of foreign exchange reserves and the total foreign exchange receipts. In order to determine or to estimate these relationship, both theoretically and empirically, these variables are known to be related to energy demand.

There are two major steps in formulating the regression analysis: First identify the independent variables and postulate tentative estimating relationship, between the demand and the independent variables like price and income (GDP share of each sector in case of sectoral demand equation). Second, examine the efficiency of the estimate of the fit and adjust the relationships so that they explain as much as possible the variance in variables to be estimated, yet do not violate any of the assumptions of a regression analysis.

Lagged variables of foreign exchange reserves and total quantity of imports were introduced in the second part to correct for multicolleneartity problem.

4.1.5 The independent variables :-

Demand for primary and commercial energy such as crude oil are assumed to be based on demand by consumers for final demand of the products such as gasoline, electricity. The Sudan demand model is therefore structured to estimate demand for final products, under the assumption that they represents real value. The modelling structure assumes that energy demand is sensitive mainly to energy price and income.

For the second part which explores the endogenous price assumption on the basis of a simultaneous equation techniques supply-demand equations. In this part additional independent variables were added these include the lagged volume of foreign exchange reserves and foreign exchange receipts and the lagged volume of total petroleum products imports.

Each of the relationship is predicted on the assumption that energy demand curves are downward sloping i.e. demand decreases as price increase, and increases when price decrease. The quantitative forms of these relationships are derived from historical data that cover the period (1980-1993) for prices, per capita income (or Disposable income) or GDP share of each sector, and the end use of total energy consumed.

4.1.6 The Double Logarithmic Demand Function: The justification of the Model :-

"Although that linear demand functions used for simplicity and convenience reasons, however, actually when we use the historical data to estimate demand functions, the linear form has some disadvantages, one of these is that the estimated values for the parameters giving the response of quantity demanded to change in price or income depends only on the units in which price or income are measured. This can give rise to confusion especially when comparing demand functions. A second and related disadvantage of the linear form has to do with the measurements of sensitivity of quantity demand to changes in price and income, to be used in comparing and classifying commodities i.e. price and income elasticities, if linear demand functions of energy are used, simple comparisons of the characteristics of energy demand in different countries in term of elasticities of price and income are impossible". (Michael Common, 1988).

Elasticities of price and income varies with or according to the level of prices , incomes and quantities demanded.These problem are avoided if the demand functions is given in a log form. If the demand equation in exponential formula i.e. if $Q= aY^{b} P^{-c}$, then taking the log to the both sides, the function could be written as follows:

LogQ= Log a + b Log Y - c log P, or taking the natural logarithm

Ln Q= Ln a + b Ln Y - c Ln P, which could be written as

Ln Q= a + b Ln Y - c Ln P,

with this double Logarithmic demand function, the price and income elasticities are constants for all values of Y and P and we have

P_e = -c (price elasticity), Y_e = b (income elasticity).

so estimating the value of c and b, gives directly prices and income elasticities of demand for energy function.

Thus the double Logarithmic demand function is convenient, because the estimated values of b and c are unaffected by the unit in which Y and P are measured.

The model used the natural Logarithms of income, price and quantity demand (consumed) for the major three types of energy consumed in the Sudan including biomass, electricity and petroleum products covering the period (1980-1989) and (1980-1993).

4.1.7 The assumption of Constant Elasticity :-

Constant demand elasticities are assumed, i.e. the percentage change in demand is considered to be the same for a given percentage change in price, income (or individual sectoral share in GDP). Thus the general form of the estimating equations used in the model measures constant elasticity is

$D= aY^{b}P^{-c}$

D = Per-capita Household demand and quantity demand for a given energy product. (Under the assumption that it represents real value)

P = price for a given energy product in Sudanese pounds.

Y= per capita income (household sector) or sectoral contribution in GDP in Sudanese pounds.

For the second part of the present chapter, two structural (simultaneous) supply-demand equations are used to test the assumption that the price of petroleum products or oil as imported good in Sudan is endogenously determined by the availability of foreign exchange receipts, the two structural equations are:

$$\text{Ln } M^{d}_{t} = a_0 + a_1 \text{ Ln } (Pm_t / p_t)_t + a_2 \text{ Ln } Y_t + a_3 \text{ Ln } m_{t-1} + U_t$$

$$\text{Ln } M^{s}_{t} = b_0 + b_1 \text{ Ln } F_t + b_2 \text{ Ln } R_{t-1} + b_3 \text{ Ln } (Pm_t /p_t)_t + b_4 \text{ Ln } m_{t-1} + V_t$$

where $M^{s}_{t}= M^{d}_{t} = M_t$ in equilibrium, and $(Pm_t/P_t)_t$ are endogenous variables, F_t represent foreign exchange receipts, R_{t-1} represent the lagged end years stocks of foreign exchange reserves, U_t and V_t are demand and supply shocks (i.e. random variables) a_i, b_i ; I = 1, 2, 3 are structural parameters.[6]

The demand equation is over identified and therefore the ordinary least squares technique will produce inconsistent estimate if applied, the

[6] See PP.284- 285 (A general Import-Model with Endogenous prices, The World Bank, Economic Review (May (1989) volume (3)- No. (2) Cristian-Moran (p. 279-294).

relevant method is the two-stage Least squares method which will be more convenient estimate for the demand equation.[7],[8].

Part (1) :-

The Sectoral Demand For Energy in the Sudan:-

4.2.1 Microeconomics and Statistical Analysis of Energy Demand Function in the Sudan :-

The Estimation of Sectoral Energy Demand Functions :-

Introduction :-

This part focuses on micro-statistical analysis of energy demand function by types and by sectors. An attempt is made to estimate individually, the sectoral function for the three types of energy. For most estimated equations most estimated parameters and coefficients have their expected signs and they are consistent with theoretical predictions (consistent with the law of demand, i.e. downword sloping demand law), (except for household demand for biomass, transport sector demand for benzine and gasoil which have a positive price sign i.e. upward sloping demand curve) and in most cases the estimated parameters are statistically significant under the 5% level of significance.

4.2.1.1 The Estimation of sectoral Biomass Demand Function:-

4.2.1.1.1 The Estimated Demand for Biomass by Household sector:-

The estimated demand for biomass by household sector is given by

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[7] All the estimation process are made through using computer programming application. The study used the "SPSS for Windows" computer programme, for both the first and second part.

[8] This part basically depends on the theoretical and empirical background and studies undertaken by the World Bank and the IMF in (21) developing countries during the period (1970-1983). The present study used their method and modified where necessary.

the following equation [9]:

$$Ln\,(DB\text{-}Pc)_t = 4.007 + 0.215\,Ln\,(GDP\text{-}Pc)_t + 0.001581\,Ln(Pcc\text{-}GD)_t + U_t$$

(4.337) (1.574) (.057) eq.(1)

t = (1980-1989)

$R^2 = 0.53274$, $F = 4.56055$, $D.w = 1.04433$

where $(DB\text{-}Pc)_t$ stands for percapita demand for biomass, $(GDP\text{-}Pc)_t$ represent per-capita GDP and (Pcc-GD) stands for price of charcoal adjusted by GDP delator and used as a price index for biomass. The estimated demand for biomass by household sector when price is adjusted to GDP delator and lagged value of quantity demanded are used is given below:

$$Ln(DB\text{-}Pc)_{t-1} = 2.857 + .37037\,Ln(GDP\text{-}Pc)_t - .04238\,Ln\,(Pcc\text{-}GD)_t + U_t$$

(2.559) (2.352) (-1.016) e.q. (2)

t= (1980-1989)

$R^2 = .54196$, F=4.14126, D.W =1.12663

where $(DB\text{-}Pc)_{t-1}$ represents lagged value of quantity demanded ,$(GDP\text{-}Pc)_t$ represents per-capita GDP used as a proxy for income, and $(Pcc\text{-}GD)_t$ represent charcoal price adjusted to GDP deflator used as a proxy for biomass price.

According to the estimated equations(1), the demand for biomass by household sector have a wrong sign for price coefficient, which violate the assumption of downward sloping demand curve, this implies that demand for biomass in this sector is positively related to changes in

[9] Figures between the parenthesis represents 't' statistic value. R^2 used as a measure of correlation Coefficient or 'goodness of fit' measure i.e. explanatory power of the model. 'F' statistic represents or used as a test for the overall significance of the model. Durban- Watson- d. statistic 'D.w.d' used as a test for serial correlation, "t" represents time period. For total biomass, total energy demand, total petroleum products, biomass demand for household and industrial sectors, "t" represents the period (1980-1989), demand for furnace and gasoil by transport sector "t" represents the period (1980-1990), for the rest estimated function "t" represents (1980-1993). U_t represents the disturbance term i.e. represents the other variables affecting demand function.

income and price and this means that biomass have upward sloping demand curve for the household sector. This could be attributed to the fact that prices are so low to the extent that they do not reflect the real cost, and this implies that there is price distortion which attributed to subsidization policy during the period (1980-1989).

In the first estimated equation both the price and income coefficients are statistically insignificant under the 5% level of significance . The 'F' statistic is high and indicates that the overall model is statistically significant under the 5% level of significant. The D.W, statistic is relatively low and implies that there is a considerable positive serial correlation in the estimated residuals. The 'goodness of fit' measures R^2 suggested that the variable $(GDP\text{-}Pc)_t$ and $(Pcc\text{-}GD)_t$ together explain 0.53274 percent of the variation in the quantity demanded. In the second estimated equation both the constant term and income coefficients are statistically significant under the 5% level of significance , the price coefficient is statistically insignificant , however, the price coefficient tend to be negative and have correct sign. Moreover, the 'goodness of fit' measures R^2 was also improved and suggested that the variables $(GDP\text{-}Pc)_t$ and $(P\text{-}GD)_t$ together explain 0.54196 percent of the variation in the quantity demanded. On the other hand, the 'F' statistics is relatively less than with the first estimated equation (current value case), i.e. the value of 'F' statistics is decreased and the overall significant is declined. The D.w statistic relatively increased compared with the current value case and also implies that there is positive serial correlation in the estimated. This means that the lagged value case give relatively better results because all the estimated coefficients have correct sign and most of them are statistically significant under the 5% level of significance and this relatively improved the explanatory power of the model through improving the goodness of fit measure.

the constant income elasticity in the second estimated equation is estimated to be 0.37037, less than unity, which means that biomass is a necessary commodity for household sector and implies that total biomass demand by the sector will increase by 0.37037 percent if the per-capita GDP increases by one percent. The estimated constant price elasticity is about 0.042381 which is very low and implies that biomass is inelastic for the household and means that total demand by the household sector will increase by 0.042381 percent, if the price increase by one percent. Since both income and price elasticities are less than unity thus demand for biomass is insensitive to both income and price changes. However, it is more sensitive to income changes than to price changes because income elasticity exceeds the price elasticity. The low income elasticity indicates that at least in the short run biomass could not easily be substituted by other energy types. The positive price coefficient in the first estimated equation implies that demand will increase whatever, the price is, and this has a serious environmental implications. Therefore environmental conservation strategy in the Sudan necessitates or requires the correction of price and lowering demand for biomass.

4.2.1.1.2.The Estimated Demand for Biomass by the Industrial Sector :-

The estimated demand for biomass by the industrial sector is given below:-

$$Ln\,(DB\text{-}I)_t = 6.00547 + 0.7997\,Ln\,(GDPn)_t - 0.069\,Ln\,(Pcc\text{-}GD)_t + U_t$$

t= (1980-1989) (4.880) (4.145) (-1.933)

$R^2 = 0.83842$, F = 18.16142, D.w = 1.41410 where $(DB\text{-}I)_t$ stands for demand for biomass by the industrial sector, $(GDPn)_t$ represents the industrial sector contribution in GDP (used as a proxy for income) and $(Pcc\text{-}GD)_t$ stands for price of charcoal as a proxy for biomass price deflated by GDP deflator. The results of the estimated equation revealed that, the industrial sector total demand for biomass increases with the increase of industrial sector contribution in the Gross domestic product (GDP), but decreases with the increase of biomass (charcoal) price . According to the estimated equation the variables $(GDPn)_t$ and $(Pcc\text{-}GD)_t$ together explain .83842 percent of the variation in total quantity demanded. The D.w statistic indicates that positive serial correlation is present in the estimated residuals. The high "F" statistics strongly suggests that the overall significance of the estimated equation. The constant term coefficient and the income coefficient are statistically significant but the price coefficient is statistically insignificant under the 5% level of significance. According to the estimated equation, the constant income elasticity of biomass in this sector is estimated to be 0.7997 means that total industrial demand for biomass increase by 0.7997 percent if the contribution of industrial sector in GDP increases by one percent. On the other side, the constant price elasticity is estimated to be 0.069 this means that total industrial demand for biomass will decrease by .069 percent if the price of charcoal (biomass) adjusted to GDP deflator increases by one percent. It is clearly obvious that both income and price (constant) elasticities are less than unity, this means that the industrial sector demand for biomass is inelastic since the constant income elasticity is less than unity, therefore biomass is a necessary input (source of energy) in the industrial sector production. The low income and price elasticities implies that total demand is less sensitive to both price and income changes. However, the income effect is stronger than the price in changing industrial sector demand for biomass. Although there are some substitutes energy sources (i.e. commercial energy), but according to the estimated equation and lowest income elasticity, the primary (traditional) biomass is still significant in this sector, in this respect and under the depletion and shrinking of forests resources, the usage of commercial energy sources as a substitute for biomass will automatically serve environmental conservation objectives.

4.2.1.2. The Estimation of Sectoral Electricity Demand Function :-

Electricity as a source of commercial energy is consumed by four major sectors. The results of all the estimated equations revealed that demand for electricity is consistent with the theoretical predictions, that demand for electricity negatively correlated with electricity tariff or price.

4.2.1.2.1 The Estimated Household Electricity Demand Function :-

$D(EL\text{-}Pc)_t = 30.9377 + 0.0116\,(Yd\text{-}Pc)_t - .01675\,(P.EL\text{-}GD)_t + U_t$

t = (1980-1993) (2.642) (.273) (-2.205)

$R^2 = .30661$, F = 2.43203, D.w = .68056

where $D(EL\text{-}Pc)_t$ stands for per-capita demand for electricity at time t = (1980-1993) and $(Yd\text{-}Pc)_t$ represents per-capita disposable income, and $(P.EL\text{-}GD)_t$ represents price of electricity adjusted to GDP deflator. The results from the estimated equation demonstrated that the variables $(Yd\text{-}Pc)_t$ and $(P.EL\text{-}GD)_t$ together explain only .30661 percent of the variation in the quantity demanded. The low D.w statistic in the estimated equation strongly suggests the presence of positive first order serial correlation in the estimated residuals . The low value of 'F' statistic implies that the overall significance of the model is weak. The price and the constant term coefficients are statistically significant, but the income coefficient is statistically insignificant under the 5% level of significance.

According to the estimated equation,the household demand for electricity is linearly and positively related to the increase in per-capita disposable income and negatively related to changes in electricity price or tariff.The household demand for electricity has a constant income elasticity of .345725 which means that the total demand for electricity will increase by .345725 percent if the household disposable income increases by one percent.On the other side, the constant price elasticity was estimated to be 0.182686 which implies that the total electricity demand by household will decrease by 0.182686 percent, If electricity price or tariff increases by one percent.Since both price and income elastitcities are less than unity therefore, electricity have inelastic demand for the household sector which implies that electricity demand function is less sensitive to both income and price changes, since the constant income elasticity exceeds the constant price elasticity this means that household demand for electricity is more sensitive to changes in per-capita disposable income than to changes in price thus income change is more effective in changing electricity demand function than do price change and therefore, a one percentage increase in per-capita disposable income will be more effective in raising household electricity demand than do a one percentage decrease in price. The lowest value of income elasticity indicates that electricity is a necessary commodity for the household sector and at least in the short run cannot easily be substituted by other energy types.

4.1.2.2.2 The Estimated Commercial, Services and Public Sectors Demand for Electricity Function :-

The demand for electricity by commercial, services and public sectors is estimated by the following function:

$$Ln(DEL\text{-}Com\ \&serv)_t = -.2197 + 0.653\ Ln(GDPc)_t - 0.073\ Ln(P\text{-}GD)_t + U_t$$

t = (1980-1993) (- .044) (1.241) (- .398)

$R^2 = .28954$, $F = 2.24144$, $D.w = .63393$

When the absolute price is used the estimated equation given by the following equation :

$$Ln(DEL\text{-}Com\ \&serv)_t = 1.347 + 0.088\ Ln(GDPc)_t + 0.198\ Ln(P)_t + U_t$$

t = (1980-1993) (.654) (.302) (4 .207)

$R^2 = .72378$, $F = 14.41163$, $D.w = .72428$

where $(DEL\text{-}Com\ \&\ serv)_t$ stands for demand for electricity by commercial, services and public sectors, $(GDP)_t$ represents the commercial, services and public sectors contribution in GDP, $(P\text{-}GD)_t$ and $(P)_t$ stands for the adjusted and absolute electricity tariff or price in these sectors respectively. According to the first estimated equation the commercial, services and public sectors demand for electricity function is consistent with theoretical predictions i.e. demand for electricity increases with the increase of sectoral contribution in GDP but decreases with the increase of electricity tariff or price, however,all the estimated coefficients are statistically insignificant under the 5% level of significance .The second estimated equation is statistically significant under the 5% level of significance,but the equation violated the assumption of downward sloping demand curve. In the first estimated equation the lowest 't' value associated with the estimated coefficients implies that all the estimated coefficients are statistically insignificant under the 5% level of significance. The low (insignificant), 'F' statistics also implies weak significance in the estimated equation. Moreover, the lowest value of R^2 implies weak explanatory power for the first estimated equation compared with high explanatory power for the second estimated equation because the variables $(GDPc)_t$, $(P\text{-}GD)_t$ and $(P)_t$ together explain only .28954 and .72378 percent of the variation in the quantity demanded in the first and second estimated equations respectively. The low D.w statistics in both estimated equations indicates that positive serial correlation is present in the estimated residuals. According to the first estimated equation, the constant income elasticity of electricity demand by commercial and services sectors is approximately 0.653, which implies that total demand will increase by 0.653 percent, if the commercial, services and public sectors contribution in GDP increases by one percent.On the other side, the constant price elasticity in these sectors is estimated to be 0.073 means that total demand for electricity in these sectors will decrease by 0.073 percent if the price or tariff of electricity increases by one percent. Since both price and income constant elasticities in these sectors are very low and less than unity, therefore, demand for electricity in these sectors is inelastic and less sensitive to both income and price changes. However, the results of the estimated equation revealed that, the income effect is more effective in changing demand for electricity in these sectors than the price effect, i.e. a one percentage increase in the contribution of commercial, services and public sectors in (GDP) is more effective in raising electricity demand in these sectors than a one percentage decrease in electricity price (tariff). The lowest value of income elasticity in both estimated equations indicates that electricity is a necessary input in the commercial and services sectors and cannot easily substituted by other energy types in the short run.

4.2.1.2.3 Estimated Electricity Demand Function for the Agricultural Sector :-

The demand for electricity by the agricultural sector is estimated by the following equation:

$$Ln\,(DEL\text{-}A)_t = -16.5856 + 3.322\,Ln\,(GDPa)_t - 0.845\,Ln\,(P\text{-}GD)_t + U_t$$

t = (1990-1993) (-2.010) (3.190) (-2.719)

$R^2 = 0.61599$, $F = 8.82266$, $D.w = 1.43321$

where $(DEL\text{-}A)_t$ stands for the agricultural sector demand for electricity, $(GDPa)_t$ stands for the agricultural sector contribution in GDP and $(P\text{-}GD)_t$ represents the electricity tariff or price for the agricultural sector deflated by GDP deflator . The results from the estimated equation revealed that most estimated coefficients are statistically significant under the 5% level of significance and the variables $(GDPa)_t$ and $(P\text{-}GD)_t$ explain 0.61599 percent of the variation in the quantity demanded. The 'F' statistic is relatively high (significant) and implies that over all significance of the mode is high. The D.w statistic is low and indicates that there is positive serial correlation in the estimated residuals. The income and the price coefficients are statistically significant, but the constants term coefficient is statistically insignificant under the 5% level of significance.

According to the estimated equation the agricultural sector demand for electricity function is consistent with the theoretical predictions, i.e. the total electricity demand in the sector increases with the increase of agricultural sector contribution in gross domestic product (GDP) but decreases with the increase in electricity price or tariff. The estimated constant income elasticity is relatively high and greater than unity which means that it is income elastic and indicates that electricity is (not a necessary) or a luxury input in the agricultural sector production, the constant income elasticity is about 3.322, this means that total demand will increase by 3.322 percent if the agricultural sector contribution in GDP increases by one percent. On the other hand, the constant price elasticity is less than unity it is about .845, this means that , total demand for electricity in this sector will decrease by .845 percent if the price or tariff of electricity increases by one percent. It is clearly obvious from the estimated equation, that the demand for electricity is highly sensitive to income changes but less sensitive to price changes. This means that a one percentage increase in the contribution of agricultural sector in GDP will be more effective in raising total demand for electricity in the sector than do a one percentage decrease in the price or tariff. Since the income elasticity is greater than unity, therefore, electricity in the agricultural sector can possibly be substituted by other types of energy, i.e. the sector depends on gasoil, diesel, and furnace. The availability of substitutes energy sources raises both the income and price elasticities in this sector.

<u>4.2.1.2.4 the Estimated Electricity Demand Function for the Industrial sector :-</u>

$$\text{Ln}\,(DEL\text{-}I)_{t-1} = 2.1183 + 0.623\,\text{Ln}\,(GDPI)_t - 0.1477\,\text{Ln}\,(P\text{-}CPI)_t + U_t$$

t = (1980-1993) (.812) (1.557) (- 3.679)

$R^2 = 0.6789$, F = 10.47481, Dw =1.41089

where $(DEL\text{-}I)_{t-1}$,[10] stands for lagged value of electricity demand by the industrial sector, $(P\text{-}CPI)_t$ represents the adjusted electricity tariff or price for the industrial sector to the consumer price index (CPI), $(GDPI)_t$ represents the industrial sector contribution in GDP.

According to the estimated equation, the demand for electricity in the industrial sector is consistent with the theoretical predictions i.e. increases with the increase of the industrial sector contribution in (GDP) and decreases with the increase of electricity price or tariff. The results of the estimated equation revealed that, only the price coefficient is statistically significant,and both the constant term and income coefficients

[10] With current value case, the results of both the absolute and relative price (i.e. adjusted price by GDP deflator) are statistically insignificant under the 5% level of significance and the estimated coefficients have a wrong sign.

are statistically insignificant under the 5% level of significance because the estimated "t" value are very low for both estimated coefficients. The highest 'F' statistic value implies the high significance of the model and therefore,The model is statistically significant , moreover,the goodness of fit measure (R^2)indicates that thevariables$(P\text{-}CPI)_t$ and $(GDPI)_t$ together explain about .6789 percent of the variation in the quantity demanded . Moreover, the D.w statistics indicates that positive serial correlation is present in the estimated residuals.

According to the results of the estimated equation the lowest income and price elasticities implies that electricity have inelastic demand and electricity is a necessary input in the industrial sector production.The income elasticity is about .623 implies that the demand will increase by .623 percent if the contribution of the industrial sector in GDP increases by one percent. The price elasticity is also less than unity it is about .1477 and implies that total demand will decrease by about .1477 percent if the price or tariff increases by one percent Since both the income and the price elasticities are less than unity,this implies that the demand for electricity in the industrial sector is lesssensitive to both income and price changes,however,the income elasticity (effect) is stronger than the price elasticity(effect),and therefore industrial sector demand for electricity is more sensitive to income changes than to price changes .

4.2.1.3 The Sectoral Demand for Petroleum Products:

4.2.1.3.1The Estimated Demand for Kerosene by Household Sector

The estimated demand for kerosene by the household sector is given by the following equation :

$Ln(DKE\text{-}Pc)_t = -2.195 + 0.313\ Ln\ (GDP\text{-}Pc)_t - 0.182\ Ln\ (PKE\text{-}CPI)_t + U_t$

t = (1980-1993) (-.412) (.334) (-3.527)

$R^2 = .588$, F = 7.846, D.W = 1.89

where $(DKE\text{-}Pc)_t$ stands for per-capita kerosene demand by the household sector at time t, $(GDP\text{-}Pc)_t$ stands for real per capita income, and $(PKE\text{-}CPI)_t$ represents kerosene price related to or adjusted by the price index for private consumption at time t.

The results of the estimated equation revealed that the variables $(GDP\text{-}Pc)_t$ and $(PKE\text{-}CPI)_t$ together explain 0.588 percent of the variation in the quantity demanded. The high 'F' statistic suggests the overall significance of the model under the 5% level of significance. The constant term and the income coefficients are statistically insignificant, but the price coefficient is statistically significant under the 5% level of significance.

Since the D.w statistic is approximately '2' thus there is a very low or minimum positive serial correlation in the estimated residuals.

According to the results of the estimated equation, kerosene demand function is consistent with theoretical predictions that per-capita demand for kerosene increases with the increase in per-capita income, but decreases with the increase in kerosene price adjusted to CPI. The constant income elasticity of demand for kerosene by the household sector is estimated to be .313 which is less than unity and implies that kerosene is a necessary commodity for the household sector. On the other hand, the constant price elasticity is approximately 0.182 which means that the per-capita demand for kerosene is inelastic. Thus, the per-capita demand is insensitive to changes in price and income, however, its sensitivity to income changes is relatively higher than its sensitivity to price changes.

4.2.1.3.2 The Estimated Demand for LPG by Household Sector :-

Liquid petroleum gas been consumed only by the household sector, the estimated demand function is given by the following equation:

$$D(LPG\text{-}Pc)_t = -6550.74 + 2.353\,(Yd\text{-}Pc)_t - .030\,(P\text{-}LPG)_t + U_t$$

t = (1980-1993)   (-2.074)   (5.001)   (-1.873)

$R^2 = .72$,   F= 14.43213,   D.w = 0.54974

In natural Log form the estimated equation is defined below:-

$$Ln\,(D\text{-}LPG\text{-}Pc)_t = -8.756 + 2.021\,Ln\,(Yd\text{-}Pc)_t - 0.0695\,Ln\,(P\text{-}LPG)_t + U_t$$

t = (1980-1993)   (-1.850)   (3.776)   (-1.405)

$R^2 = 0.65008$,   F = 10.21805,   D.w = 0.47580

where $(D\text{-}LPG\text{-}Pc)_t$ stands for per-capita liquid petroleum gas demand by household at time t, $(Yd\text{-}Pc)_t$ represents real per-capita disposable income and $(P\text{-}LPG)_t$ represents $(LPG)_t$ price at time t. The price coefficient in both estimated equation are statistically insignificant due to low 't' value, the constant term is statistically significant in the first estimated equation but statistically insignificant in the second estimated equation, the income coefficient is statistically significant in both estimated equations under the 5% level of significance.

In both estimated equations the D.w statistic is very low and suggests the presence of high positive serial correlation in the estimated residuals. Both 'R^2' and 'F' statistic are relatively higher and statistically significant in the linear form equation compared with the Log form equation this implies that the linear equation is more significant than the Log equation. The variables $(Yd\text{-}Pc)_t$ and $(P\text{-}LPG)_t$ together explain 0.72 percent of the variation in quantity demanded in the linear equation compared with 0.65 percent in the Log form equation.

According to the estimated equations the demand for LPG by the household sector is consistent with theoretical predictions, that demand increases with the increase of per-capita disposable income,but decreases with the increase of LPG price.According to the second estimated equation the constant income elasticity is estimated to be 2.021, which implies that L.P.G is not a necessary good for household i.e. luxury good.On the other hand, the price elasticity is very low it is approximately 0.0695 which means that the household (per-capita) demand for LPG is inelastic and this means that total demand for liquid petroleum gas is less sensitive to price changes, but more sensitive to income changes.

4.2.1.3.3 The Estimated Demand For Benzine by Transport Sector :

The only consuming sector of benzine is the transport sector, all the product is consumed in this sector. The estimated equation is given below:-

$$\text{Ln}\,(DBT)_t = -7.245 + 2.967\ \text{Ln}\,(GDPt)_t - 0.0966\ \text{Ln}(P\text{-}GD)_t + U_t$$

t=(1980-1990) (-0.337) (0.876) (-0.405) → eq. (1)

$R^2 = 0.20759$, F = 1.04788, D.w = 2.6349.

where $(DBT)_t$ represents demand for benzine by transport sector at time t, $(GDPt)_t$ represents the transport sector contribution in GDP and $(P\text{-}GD)_t$ represents the price of benzine per gallon adjusted to or deflated by GDP deflator.

Although,the estimated equation is consistent with the theoretical predictions that demand for benzine by the transport sector increases with the increase of sectoral contribution in GDP and decreases with the increase in price.However, the results from the estimated equation revealed that all the estimated coefficients are statistically insignificant under the 5% level of significance.The overall significance of the model is very weak due to the lowest value of 'F' statistic and 'R^2' which implies that the variables $(GDPt)_t$ and $(P\text{-}GD)_t$ together explain only 0.20759 percent of the variation in the quantity demanded. Moreover, the highest value of D.w statistics, suggests the presenceof negative serial correlation in the estimated residuals.According to the estimated equation the constant income elasticity is about 2.967, which is very high and exceeds unity, this implies that benzine is a luxury good in transport sector. On the other side, the constant price elasticity is about .0966, less than unity and very low which means that the demand for benzine in the transport sector is inelastic. Since the income elasticity is greater than one and greater than the price elasticity this implies that the income effect dominate the price effect and therefore total demand for benzine is highly sensitive to income changes, but relatively insensitive to price changes.

The estimated demand for benzine by transport when the absolute benzine price per ton is used is given below:

$$Ln\ (DBT)_t = 7.434 + 0.0709\ Ln\ (GDPt)_t + 0.031\ Ln\ (P\text{-}ton)_t + U_t$$

t=(1980-1990) (5.129) (3.182) (3.581) →eq. (2)

R^2 =.75613, F=12.40223 , D.W=.89426

Where (P-ton) stands for benzine absolute price per ton.

The estimated demand for benzine by transport when the adjusted benzine price per ton is used is given below:

$$Ln\ (DBT)_t = 4.671 + 1.155\ Ln\ (GDPt)_t + 0.46\ Ln\ (P\text{-}ton\text{-}GD)_t + U_t$$

t=(1980-1990) (1.854) (3.02) (1.701) →equation (3)

R^2 =.53373, F=4.57881 , D.W=1.39851

Where (P-ton-GD) stands for adjusted benzine price per ton

According to the results of the estimated equation (2) and (3) all the estimated coefficients in equation(2) and only the income coefficient in equation (3), are statistically significant(t values is very high) and the overall significance of the model was also improved i.e. the 'F' statistic is high and increased which indicates the improvement in the power and significance of the overall model. Moreover, R^2 is highly increased and means that the variables $(GDP)_t$ and $(P\text{-}ton)_t$ in equation (2) and $(GDP)_t$ and $(P\text{-}ton\text{-}GD)_t$ together explain .75613 and .53373 percent of the variation in the quantity demanded in equation (2) and (3) respectively.

However, the D.w statistic is substantially declined and suggests the presence of high positive serial correlation in the estimated residuals in equation (2) and (3) . The estimated equation (2) and (3) also revealed a wrong sign for the price coefficient and thus violated the theoretical predictions that demand for benzine will decrease if the absolute and adjusted price per-ton increased, this attributed to price subsidization policies and price distortion, i.e. price of benzine did not reflect the real cost of importation because of governmental policy of subsidizing benzine product during the study period (1980-1990) . The result from the estimated equation (2) and (3) suggested a constant income elasticity of about .0709 and 1.155 in equation (2) and (3) respectively which implies that benzine is a necessary good with the absolute price per ton i.e. equation(2) but a luxury good (with the adjusted price per ton) i.e. equation (3). On the other side, the constant price elasticity is about .031 and .46 in equation (2) and (3) respectively, which is very low and indicates that the demand for benzine in transport sector is inelastic, and the demand for benzine will increase by .031 and .46 percent, if the absolute and adjusted price per ton respectively increases by one percent. The demand for benzine is insensitive to both income and price changes, however, the effect of income changes in total demand is greater than the effect of price changes[11]. Therefore, a one percentage increase in transport sector contribution in GDP is more effective in changing the total demand for benzine than a one percentage decrease or changes in benzine price.

[11] The estimated demand for benzine as a function of the contribution of transport sector in GDP (income factors) and absolute benzine price per ton gives statistically more significant results than the estimated demand as a function of income factor (GDP) and benzine price per gallon and per ton adjusted to GDP deflator. However, when the absolute price per ton is used the demand curve tend to have an upward slope i.e. benzine demand is positively related to price change.

4.2.1.3.4 The Estimated Demand For Gasoil :-

4.2.1.3.4.1 The Estimated Demand For Gasoil by the Agricultural Sector :-

The estimated gasoil demand by the agricultural sector is given below :

$Ln\,(DGA)_t = 10.776 + 0.237\,Ln\,(GDPa)_t - 0.0545\,Ln(P)_t + U_t$

t=(1980-1993) (4.716) (.731) (- 1.368)

$R^2 = .16728$, F = 1.10482, D.w = 2.09508

where $(DGA)_t$ stands for demand for gasoil by the agricultural sector at time t, $(GDPa)_t$ represents the agricultural sector contribution in GDP at time t, and $(P)_t$ represents absolute gasoil price at time t[12].

The results from the estimated equation revealed that the demand for gasoil by the agricultural sector is consistent with the theoretical predictions, that the demand for gasoil increases with the increase of agricultural sector contribution in GDP but decreases with the increase in gasoil price. The D.W statistics is approached '2' which means that there is no serious serial correlation in the estimated residuals.

The results from the estimated equation revealed that, both the estimated price and income coefficients are statistically insignificant due to the lowest 't' values, only the constant term is statistically significant under the 5% level of significance. Moreover, the lowest value of 'F' statistic also indicates that the overall significance of the model is very low or weak, and the lowest R^2 value also implies that the variables $(GDPa)_t$ and $(P)_t$ together explain only .16728 percent of the variation in the quantity demanded.

[12] With relative price the results are statistically insignificant under the 5% level of significance and the estimated coefficients have a wrong sign.

According to the estimated equation the demand increases with the increase of agricultural sector contribution in GDP and decreases with the increase of gasoil price, namely, that the total demand by the sector will increase by .237 percent, if the agricultural sector contribution in GDP increases by one percent, and the total demand will decrease by 0.0545 percent if gasoil price increases by one percent. Thus the total demand for gasoil in the agricultural sector is relatively less sensitive to changes in price and income. If these results used to predict the impact of policies used to manage the economy, i.e. gasoil demand management polices aims to reduce gasoil consumption in the agricultural sector implies that the reduction of consumption by one percent requires the increase of gasoil price by 0.20 percent .According to the results of the estimated equation the income elasticity exceeds the price elasticity, in this respect the reduction of agricultural sector contribution in GDP will be more effective in controlling or managing gasoil demand by the agricultural sector than the increase of price.

4.2.1.3.4.2 The Estimated Demand For Gasoil by the Transport sector :-

The estimated gasoil demand function by the transport sector is given below:

$$Ln\ (DGT)_t = 10.917 + 0.114\ Ln\ (GDP)_t - 0.201\ Ln\ (P)_t + Ut$$

t=(1980-1990) (17.359) (2.236) (-2.971) e.q. (1)

R^2= 0.47683, F= 5.01277, D.w= 1.13718.

where $(DGT)_t$ stands for demand for gasoil by transport sector at time t, $(GDP)_t$ represents total GDP and $(P)_t$ represents gasoil price at time t . According to the estimated equation total demand for gasoil by transport sector is negatively related to gasoil price and positively related to the increase of transport sector contribution in GDP. Namely that the total demand by the sector will increase by .114 percent if the transport sector contribution in GDPincreases by one percent,and the total demand will decrease by .201 percent if the price of gasoil increases by one percent Thus the total demand for gasoil in the transports sector is relatively less sensitive to changes in price and income,since the price elasticity is less than unity, therefore demand for gasoil in this sector is inelastic, and since the income elasticity is very low and less than unity this implies that gasoil is a necessary input in the transport sector. Compared with the agricultural sector, gasoil price elasticity in the transport sector is greater than the price elasticity in the agricultural sector, but the income elasticity in the agricultural sector is greater than the income elasticity in the transport sector.This implies that gasoil demand elasticity in transport sector is greater than that of agricultural sector, because the availability of other substitutes like benzine, furnace and diesel raises the price elasticity.For the agricultural sector the lowest availabilityof substitutes lead to a reduction or decline in the price elasticity .

Since the income elasticity in the agricultural sector exceeds the income elasticity in the transport sector this implies that gasoil is more necessary or required in the transport sector relative to the agricultural sector, thus demand management policy directed for managing gasoil demand requires the direction of gasoil to the transport sector at the expense of the agricultural sector i.e. transport sector must be given priority in gasoil sectoral distribution.

Using the absolute price of gasoil (per-ton) in the transport sector the estimated equation is given below:

$$Ln\,(DGT)_t = 10.90 + 0.054\,Ln\,(GDPt)_t + 0.233\,Ln\,(P\text{-}ton)_t + U_t$$

t=(1980-1990) (33.173) (2.694) (6.680) e.q. (2)

$R^2 = 0.84999$, $F = 25.49873$, $D.w = 2.22663$

where $(P\text{-ton})_t$ stands for the absolute price of gasoil per-ton.

In the above estimated equation the price coefficient have a wrong sign and therefore violated the assumption of downward sloping demand curve.[13] The results in the second estimated equation are statistically more significant compared with the first estimated equation in which income coefficient is statistically insignificant under the 5% level of significance. The overall significance of the model is also improved in the second estimated equation, the 'F' statistics is very high and statistically more significant in the second estimated equation compared with the first estimated equation. The measure of 'goodness of fit' (R^2) is also improved in the second estimated equation, compared with the first estimated equation because the variable GDP and price together explain about 0.84999 percent of the variation in the quantity demanded in the second estimated equation. Moreover, the D.w statistic increased substantially in the second estimated equation and indicates a negative serial correlation compared with a positive serial correlation in the first estimated equation. The second estimated equation is statistically more significant than the first estimated equation. However, the second estimated equation have a wrong price sign which means that the demand for gasoil in transport sector will increase what ever the price is, this attributed to the presence of price distortion and due to subsidization policies, thus prices did not reflect the real costs of supply during the study period.

According to the second estimated equation,the total demand by the sector will increase by 0.54 percent,if the transport sector contribution in

[13] In the second estimated equation the price and quantity demanded vary in the same direction i.e. demand curve have upward slope and gasoil demand is positively related to price changes. With relative price per ton the results are statistically insignificant under the 5% level of significance and the estimated coefficients have a wrong sign.

GDP increases by one percent and the total demand will decrease by .233 percent, if gasoil price increases by one percent. The price elasticity derived from the second estimated equation is greater than the price elasticity derived from the first estimated equation, but the income elasticity derived from the second estimated equation is less than the income elasticity derived from the first estimated equation. In the second estimated equation, gasoil demand by the transport sector have a greater price elasticity than gasoil price elasticity by the agricultural sector i.e. gasoil is more elastic in transport sector relative to agricultural sector. However, the income elasticity in transport sector is less than the income elasticity in the agricultural sector i.e. gasoil is more necessary for transport sector compared to the agricultural sector. Therefore gasoil demand management policy must give top priority to the transport sector in relation to the other sectors.

4.2.1.3.5 The Estimated Demand for Diesel :-

4.2.1.3.5.1 The Estimated Demand for Diesel by the Agricultural Sector :-

The estimated demand for diesel by the agricultural sector is given below:-

$Ln\,(DDA)_t = -19.49 + 3.99\,Ln\,(GDPa)_t - 0.4894\,Ln\,(P\text{-}D)_t + U_t$

t=(1980-1993) (-1.970) (2.851) (-2.818)

$R^2 = .44740$, F= 4.45297, D.w= 2.53745

where $(DDA)_t$ stands for demand for diesel by the agricultural sector, $(GDPa)_t$ represents the agricultural sector contribution in GDP, and $(P\text{-}D)_t$ represents absolute price of diesel at time t.[14]

[14] With relative price the results are statistically insignificant under the 5% level of significance and the estimated coefficients have a wrong sign.

According to the estimated equation, total diesel demand by the agricultural sector increases with the increase of agricultural sector contribution in GDP but decreases with the increase of diesel price. The total demand for diesel in the agricultural sector will increase by 3.99 percent, if the agricultural sector contribution in GDP increases by one percent, and the total demand for diesel in the sector will decrease by 0.4894 percent if diesel price increases by one percent. Thus the total demand is highly sensitive to income changes, the constant income elasticity exceeds unity it is about 3.99, the availability of the other substitutes raises the income elasticity in this sector and implies that diesel is a luxury good or not a necessary input in the agricultural sector, due to the availability of other substitutes e.g. gasoil and electricity. On the other side, the price elasticity is less than unity, it is about .4894 which implies that diesel demand by the agricultural sector is inelastic. Since the income elasticity is greater than one and exceeds the price elasticity thus income effect is stronger than the price effect,and therefore the agricultural sector demand for diesel is highly sensitive to income changes but less sensitive to price changes.This implies that a one percentage increase in the contribution of agricultural sector in GDP is more effective in raising demand than a one percentage decrease in price. The constant term coefficient is statistically insignificant, but the price and income coefficients are statistically significant under the 5% level of significance. The 'F' statistic is significant and indicates that the over all model is statistically significant.The 'goodness of fit' measures is relatively low and indicates that the variable $(GDPa)_t$ and $(P\text{-}D)_t$ together explain only 0.44740 percent of the variation in the quantity demanded. The D.w statistic is relatively high and this indicates the presence of negative serial correlation in the estimated residuals.

4.2.1.3.5.2The Estimated Demand for Diesel by the Industrial

The estimated demand for diesel by the industrial sector is given below:

$$Ln\,(DDI)_t = -17.4145 + 3.798\,Ln\,(GDPI)_t - 0.285 Ln\,(P\text{-}D\text{-}GD)_t + U_t$$

t= (1980-1993) (-1.471) (2.262) (-.844)

$R^2 = .43600$, F= 4.25185, D.W = 1.8845

Where $(DDI)_t$ stands for demand for diesel by the industrial sector, $(GDPI)_t$ represents the industrial sector contribution in GDP and $(P\text{-}D\text{-}GD)_t$ represents the adjusted diesel price (by GDP deflator) at time t.

According to the results of the estimated equation, total demand for diesel by the industrial sector is consistent with the theoretical predictions i.e. diesel demand increases with the increase of the industrial sector contribution in GDP but decreases with the increase of adjusted diesel price. The income elasticity is about 3.798 which is very high and greater than unity (due to availability of other substitutes), this implies that diesel is a luxury or (not a necessary) good or input in the industrial sector production, this implies that total demand for diesel in this sector will increase by 3.798 percent if the industrial sector contribution in GDP increase by one percent.On the other side, the price elasticity is about .285 which implies that total diesel demand in this sector will increase by .285 percent if the adjusted diesel price increases by one percent. Since the price elasticity is very low and less than unity therefore,demand for diesel in the industrial sector is inelastic.Since the income elasticity is greater than one and exceeds the price elasticity, therefore the income effect dominate the price effect and the total demand is highly sensitive to income changes than to price changes. The availability of the other substitutes energy types or sources (like furnace, electricity and biomass) lead to the increase of diesel demand elasticity in the industrial sector.

The D.w statistics approached '2' and therefore there is no serious or considerable serial correlation in the estimated residuals. The 'goodness of fit measures' R^2 is very low and implies that the variables $(P\text{-}D\text{-}GD)_t$ and $(GDP)_t$ together explain about .43600 percent of the variation in the quantity demanded. The 'F' statistic is relatively high and implies that the overall model is statistically significant under the 5% level of significance. The results from the estimated equation revealed that both the constant term and the price coefficients are statistically insignificant, but the income coefficient is statistically significant under the 5% level of significance.

Diesel income elasticity in the agricultural sector exceeds the price elasticity in the industrial sector due to the availability of other substitutes. Moreover, the price elasticity in the industrial sector is less than the price elasticity in the agricultural sector. Thus diesel is less elastic and more required in the industrial sector production or operations relative to the agricultural sector. Thus diesel demand management policy must give priority to the industrial sector relative to the other sectors.

4.2.1.3.6 The Estimated Demand for Furnace:-

4.2.1.3.6.1 The Estimated Demand for Furnace by the Industrial sector :-

The estimated demand for furnace by the industrial sector is given by the following equation :

$$Ln\,(DFI)_t = .7576 + 1.594\,Ln\,(GDPI)_t - 0.0963\,Ln\,(P\text{-}F\text{-}GD)_t + U_t$$

t= (1980-1993) (.352) (5.119) (-1.504)

R^2 = .78145, F = 19.66571, D.w = 1.41534

Where $(DFI)_t$ stands for demand for furnace by the industrial sector at time t and $(GDPI)_t$ represents the industrial sector contribution in GDP and $(P\text{-}F\text{-}GD)_t$ represents adjusted furnace price (by GDP deflator) at time t.

According to the results of the estimated equation the income coefficient is statistically significant, but the constant term and the price coefficients are statistically insignificant under the 5% level of significance. The high 'F' statistic suggested that the over all model is statistically significant , moreover, the 'goodness of fit measures' R^2 is relatively high and implies that the variables $(GDPI)_t$ and $(P\text{-}F\text{-}GD)_t$ together explain about 0.78145 percent of the variation in the quantity demanded. On the other side, the D.w statistic implies that positive serial correlation is present in the estimated residuals.

The results of the estimated equation revealed that the demand for furnace by the industrial sector is consistent with the theoretical predictions which implies that the total demand for furnace by the industrial sector increases with the increase of industrial sector contribution in GDP but decreases with the increase of furnace price. The income elasticity is greater than unity, this implies that furnace is (not a necessary) or a luxury good or input in the industrial sector, the estimated income elasticity is about 1.594, which implies that the total demand for furnace in this sector will increase by 1.594 percent if the industrial sector contribution in GDP increases by one percent. On the other side, the constant price elasticity is very low and less than unity and implies that furnace have inelastic demand in the industrial sector. The estimated price elasticity is about .0963 which means that, the total demand for furnace in the industrial sector will increase by .0963 percent if the adjusted furnace price (by GDP deflator) increases by one percent. Thus the total demand for furnace in this sector is relatively sensitive to income changes and relatively less sensitive to price changes.

4.2.1.3.6.2 The estimated Demand for Furnace by the Transport Sector :-

The estimated demand for furnace by the transport sector is given below :-

$$\text{Ln }(DFT)_t = 10.92075 + 0.33 \text{ Ln }(GDPt)_t - 0.506 \text{ Ln }(P\text{-}F)_t + U_t$$

t= (1980-1990) (1.695) (0.324) (-3.223)

R^2= .60033, F = 6.00834, D.w= 1.11592

Where$(DFT)_t$ stands for demand for furnace by the transport sector at time t,$(GDP)_t$represents the transport sector contribution in $(GDP)_t$ at time t,and $(P\text{-}F)_t$represents the absolute price of furnace at time t.[15]

The results from the estimated equation revealed that both the constant term and the income coefficient are statistically insignificant, but the price coefficient is statistically significant under the 5% level of significance.The 'F' statistic is relatively high and indicates that the overall model of estimate is statistically significant.Moreover,the goodness of fit measures (R^2),implies that the variables $(P\text{-}F)_t$ and $(GDPt)_t$ together explain about 0.60033 percent of the variation in the quantity demanded.The D.w statistic suggests the presence of a considerable positive serial correlation in the estimated residuals.

According to the estimated equation the total demand for furnace by the transport sector is consistent with the theoretical predictions,that total demand in this sector increases with the increase of the transport sector contribution in GDP,but decreases with the increase of furnace price.The constant income elasticity is about 0.33,less than unity which implies that furnace is a necessary good or input in the transport sector,and the total demand for furnace in this sector will increase by 0.33 percent if the

[15] With relative price the results are statistically insignificant under the 5% level of significance and the estimated coefficients have a wrong sign.

contribution of the transport sector in GDP increases by one percent. On the other side, the price elasticity is about 0.506, which is less than unity and this implies that in the transport sector the demand for furnace is inelastic and implies that the total transport sector demand for furnace will decrease by 0.506 percent if furnace price increases by one percent. Since both income and price elasticities are less than unity, this implies that the total demand for furnace is relatively insensitive to both income and price changes. Since the price elasticity is greater than the income elasticity, this means that a one percentage decrease in furnace price is more effective in raising demand than a one percentage increase in the transport sector contribution in (GDP) i.e. the total demand in this sector is more sensitive to price changes than to income changes.

Furnace demand by the transport sector have price and income elasticities less than unity, but furnace demand by the industrial sector have price elasticity less than unity and income elasticity greater than unity. Therefore, the sensitivity of furnace demand to changes in income is greater in the industrial sector compared to the transport sector i.e. furnace is a necessary input in the transport sector but a luxury input in the industrial sector. On the other side, furnace demand sensitivity to price change is greater in the transport sector compared to that in the industrial sector. Furnace price elasticity in the transport sector exceeds the price elasticity in the industrial sector. However, the income elasticity in the industrial sector is greater than the income elasticity in the transport sector i.e. furnace is more necessary in the transport sector than in the industrial sector and therefore furnace demand management must put or give priority to the transport sector relative to the industrial sector or the other consuming sectors.

4.2.2. Macroeconomic and Statistical Estimation of Aggregate Energy Demand Function :

(Aggregate Energy Demand Function by Types) :-

This part focuses on the estimation of the aggregate energy demand function for the three types of energy, including biomass, electricity and total petroleum products and finally the total energy demand function (i.e. the aggregate energy demand function) in the Sudan.

4.2.2.1 The Estimated Aggregate(total) Biomass Demand Function:

The estimated aggregate (total) biomass demand function is given below:-

$$Ln\ (DB)_t = 9.35 + .801\ Ln\ (GDP)_t - 0.0711\ Ln\ (Pcc\text{-}GD)_t + U_t$$

t=(1980-1989) (7.583) (4.141) (-1.982)

$R^2 = .84$, $F = 18.38077$, $D.w = 1.42917$

Where $(DB)_t$ stands for demand for total biomass at time t, $(GDP)_t$ represents GDP at time t, and $(Pcc\text{-}GD)_t$ represents the price of charcoal (as a proxy for biomass price) adjusted to GDP deflator at time t.

The results from the estimated equation revealed that both the constant term and the income coefficients are statistically significant, but the price coefficient is statistically insignificant under the 5% level of significance.The 'F' statistic is relatively high and significant under the 5% level of significance, this implies that the over all model is statistically significant.Moreover, the 'goodness of fit' measure R^2 is very high and indicates that the variable $(GDP)_t$ and $(Pcc\text{-}GD)_t$ together explain about 0.84 percent of the variation in the quantity demanded.The D.w statistic implies that there is a considerable positive serial correlation in the estimated residuals.

According to the results of the estimated equation the aggregate demand for biomass is consistent with the theoretical predictions, that the total demand for biomass increases with the increase of GDP but decreases with the increase of biomass price.The total demand for biomass will increase by .801 percent if the(GDP)gross domestic product increases by one percent and total demand for biomass decreases by 0.0711 percent if the adjusted biomass price(i.e. the adjusted charcoal price to GDP-deflator) increases by one percent.The income elasticity is less than one, estimated to be .801 which implies that biomass is a necessary commodity or good in the Sudan during the period (1980-1989), on the other side, the price elasticity is less than unity it is about 0.0711, this implies that the total or aggregate demand for biomass is inelastic.Since the income elasticity exceeds the price elasticity, therefore total demand for biomass is more sensitive to changes in income and less sensitive to changes in price.This implies that a one percentage increase in GDP is more effective in raising total demand for biomass than a one percentage decrease in price. Since both the income and price elasticities are less than unity during the period (1980-1989), therefore demand for biomass is insensitive to both income and price changes, in this respect and under the depletion and shrinking of forests resources,the usage of commercial energy sources as a substitute sources for biomass will automatically serve environmental conservation objectives.

4.2.2.2. The Estimated Aggregate Demand for Electricity Function:

The aggregate electricity demand function is estimated by using aggregate data for the period (1980-1993) and (1980-1991) on total electricity consumed in the Sudan, GDP as a proxy for income and a weight price index for electricity deflated by GDP deflator (used as a proxy for electricity price), the estimated equation is given below:

$$Ln\ (DEL)_t = -9.199 + 1.853\ Ln\ (GDP)_t - 0.185\ Ln\ (PEL\text{-}GD)_t + U_t$$

t=(1980-1993) (-1.457) (2.808) (-.140)

$R^2 = 0.55118$, $F= 6.75449$, $D.w= .54392$ → equation (1)

Aggregate electricity equation during the period (1980-1991) is given below :

$$Ln\,(DEL)_t = 5.456 + .276\,Ln\,(GDP)_t - 0.165\,Ln\,(PEL\text{-}GD)_t + U_t$$

t=(1980-1991) (.260) (.123) (-.675)

$R^2 = 0.23987$, $F= 1.42002$, $D.w= .55514$ → equation (2)

Where $(DEL)_t$, stands for aggregate electricity demand, $(GDP)_t$ represents the gross domestic product and $(PEL\text{-}GD)_t$ represents the weight average price of electricity adjusted or deflated by GDP deflator.

According to the results of the estimated equations, under the 5% level of significance only the income coefficient is statistically significant in the first estimated equation,and all the estimated coefficients are statistically insignificant in the second estimated equation.The highest value of 'F' statistic in the first estimated equation indicates that the overall model is statistically significant under the 5% level of significance and the low value of 'F' statistic in the second estimated equation indicates that the overall model statistically insignificant under the 5% level of significance .Moreover, the goodness of fit measures (R^2) in the first estimated equation relatively high compared with the second estimated equation and indicates that the variables $(GDP)_t$ and $(PEL\text{-}GD)_t$ together explain about .55118 and .23987 percent of the variation in the quantity demanded in the first and second estimated equations respectively.The D.w statistic in the estimated equations indicates that there is a high positive serial correlation in the estimated residuals.

According to the estimated equations the price coefficient have the expected and correct sign which implies negative relationship between price and quantity. This means that total demand for electricity is negatively related to price changes and positively related to income changes. According to the results of the estimated equations the income effect exceeds or dominates the price effect and therefore, total electricity demand is more sensitive to income changes than to price changes, this means that a one percentage increase in gross domestic product is more effective in raising total demand for electricity than a one percentage decrease in electricity price index. The constant income elasticity in the second estimated equation is less than unity, which implies that during the period (1980-1991) electricity is a necessary good or commodity (i.e. source of energy) in the Sudan. The estimated income elasticity was about .276, implies that, the total electricity demand will increase by .276 percent if the gross domestic product increases by one percent, however, in the first estimated equation The constant income elasticity is greater than unity, which implies that during the period (1980-1993) electricity is a luxury or not a necessary good or commodity (i.e. source of energy) in the Sudan. The estimated income elasticity in the first equation was about 1.853, implies that, the total electricity demand will increase by 1.853 percent if the gross domestic product increases by one percent. On the other hand, the estimated price elasticity in the estimated equations is relatively low which means that the demand for total electricity in the Sudan is inelastic. The estimated price elasticity is about .0185 in the first estimated equation and about .165 in the second estimated equation and this means that the total electricity demand will increase by .0185 percent in the first estimated equation and .165 percent in the second estimated equation if the adjusted weight price index for electricity increases by one percent in the first and second estimated equations respectively.

4.2.2.3 The Estimated Aggregate (total) Petroleum Products Demand Function :-

The aggregate petroleum products demand by all sectors is estimated by using aggregate data for the period (1980-1989) on total petroleum products consumed in the Sudan(demand for six products excluding avgas and Jet-AI), using GDP as a proxy for income and (a unified) petroleum products price index[16].The estimated equation for total petroleum products consumed by all sectors is given below:-

$$Ln(DPP)_t = 3.405 + 0.071 Ln\,(GDP)_t - 0.0657 Ln\,(PP\text{-}index\text{-}GD)_t + U_t$$

$$t = (1980\text{-}1989) \quad (30.323) \qquad (1.453) \qquad (-1.734)$$

$$R^2 = 0.30067, \qquad F = 2.57966, \quad D.w = .47517$$

Where $(DPP)_t$ stands for aggregate demand for petroleum products at time t, $(GDP)_t$ stands for Gross domestic products and $(PP\text{-}index\text{-}GD)_t$ represents a weight price index of six product adjusted to or deflated by GDP deflator at time t.

According to the estimated equation the income and the price coefficients are statistically insignificant under the 5% level of significance, but the constant term coefficient is statistically significant under the 5% level of significance. The 'F' statistic is very low and implies that the over all model is statistically insignificant under the 5% level of significance. The measure of 'goodness of fit' 'R^2' is very low and indicates that the variables $(GDP)_t$ and $(PP\text{-}index\text{-}GD)_t$ together explain about 0.30067 percent of the variation in the quantity demanded. The D.w statistic is very low and suggests that a considerable positive serial correlation is present in the estimated residuals.

[16] A unified (weight) average petroleum products price index was introduced as a proxy for total Petroleum products price index. The price index includes the price of six products i.e. include benzine, diesel, LPG, Gasoil, Furnace and kerosene. The price index did not include and consider the price of Jet-AI and Avagas because in most years no information are available about their prices.

According to the estimated equation the aggregate demand for petroleum products in Sudan is consistent with theoretical prediction that the aggregate petroleum products demand increases with the increase of GDP but decreases with the increase of petroleum products adjusted price index. The constant income elasticity was about 0.071 was very low and less than unity, this means that petroleum products are necessary commodity or input for all consuming sectors in the Sudan. The estimated income elasticity is about 0.071 which implies that aggregate petroleum products demand increases by 0.071 percent if the (GDP) gross domestic product increases by one percent. On the other side, the constant price elasticity is very low relative to income elasticity, it is about 0.0657 less than unity, this means that aggregate petroleum products demand will decrease by 0.0657 percent if the adjusted price index of petroleum products increases by one percent. Since both income and price elasticities are less than unity, therefore the aggregate demand for petroleum products is less sensitive to both income and price changes, however, it is more sensitive to income changes than to price changes because the income elasticity exceeds the price elasticity.

2.2.4 The Estimated Aggregate (total) Demand For Energy Function in the Sudan:-

The aggregate (total) energy demand function by all sectors in the Sudan is estimated by using aggregate data for the period (1980-1989) i.e. by using the aggregate (total) consumption of the three sources of energy (i.e. total energy consumption) by all sectors in Sudan, these include total consumption of biomass, electricity and petroleum products, GDP used as a proxy for income and a weight average price index used as a proxy for aggregate energy price. The estimated aggregate energy demand function with the absolute price index is given by the following equation :-

$$Ln\ (DAEn) = 6.1356 + 0.937\ Ln\ (GDP)_t + .101\ Ln\ (P\text{- index})_t + U_t$$

t= (1980-1989) (3.786) (5.025) (8.113) → eq. (1)

$R^2 = 0.93356$, F= 49.17962 , D.w = 2.34019

The estimated aggregate energy demand function when the price index is adjusted to or deflated by GDP deflator is given by the following equation :

$$Ln\ (DAEn)_t = 7.676 + .912\ Ln\ (GDP)_t - 0.0186\ Ln\ (P\text{-index-GD})_t + U_t$$

t=(1980-1989) (0.859) (0.941) (-.194) →eq.(2)

$R^2 = 0.31254$, F= 1.59121 , D.w = .33666

Where $(DAEn)_t$ stands for aggregate energy demand in the Sudan at time t, $(GDPt)_t$ stands for gross domestic products and $(P\ index)_t$ in the first estimated equation represents absolute price index and $(P\text{- index-}GD)_t$ represents the adjusted or deflated weight average price index.

The results derived from the first estimated equation are statistically significant all the estimated coefficients are statistically significant under the 5% level of significance. In the second estimated equation, the price coefficient have a correct sign and consistent with the law of downward sloping demand curve, however, all the estimated coefficients are statistically insignificant under the 5%, and the 'F' statistic is very low indicating that the overall significance of the model is very low or weak.

In the first estimated equation the 'F' statistic is very high and all the estimated coefficients are statistically significant under the 5% level of significance. The 'goodness of fit' measure in the first estimated equation (with the absolute price-index) is very high compared with the second estimated equation (i.e. adjusted price case). For the first estimated equation the variables $(GDP)_t$ and $(P\text{-index})_t$ together explain about 0.93356 percent of the variation in the quantify demanded. But in the second estimated equation (with the adjusted price-index) the variables

$(GDP)_t$ and $(P\ index\ \text{-}GD)_t$ together explain only 0.31254 percent of the variation in the quantity demanded.

The D.w statistic is a very low in the second estimated equation estimated equation and means that a very high positive serial correlation is present in the estimated residuals. However, the D.w statistic is very high in the first estimated equation compared with the second estimated equation and implies that there is negative serial correlation in the estimated residuals.

The results from the estimated equations revealed that the aggregate energy demand function with absolute price index is statistically significant uder the 5% level of significance, but inconsistent with the theoretical predictions that aggregate energy demand decreases with the increase of absolute price index. On the other side, the aggregate demand function with adjusted price index is statistically insignificant but consistent with the theoretical predictions that the aggregate demand for energy decreases with the increase of adjusted price index. The price coefficient have the expected sign, this means that there is negative relationship between aggregate energy demand and energy price, i.e. energy in Sudan have a normal downward sloping demand curve.With the absolute price index, the aggregate energy demand will increase with the increase of price i.e. there is price distortion and that the absolute energy price index did not reflect the real costs of production or generation (supply), this could be attributed to the fact that for most energy types prices are subsidized by government during the study period, (i.e. for the period (1980-1989) there is price subsidy and therefore price distortion).

In the first estimated equation with the absolute price index the income elasticity is about 0.937 is less than one which means that energy is a necessary commodity or input for all consuming sectors in the Sudan, and that total or aggregate energy demand will increase by 0.937 percent if the GDP increases by one percent. On the other side, the price elasticity is estimated to be about 0.101, which is very low and indicates that the aggregate demand for energy in the Sudan is relatively inelastic and that the aggregate demand for energy will increase by .101 percent if the absolute price index increases by one percent. Since both income and price elasticities are less than unity this means that aggregate demand for energy is less sensitive to both income and price changes. However, it is more sensitive to income changes than to price changes, because the income elasticity exceeds the price elasticity.

In the second estimated equation with the adjusted price index the income elasticity decreased compared to the absolute price case, it was about .912 i.e. the aggregate demand will increase by .912 percent if the GDP increases by one percent. On the other side, the price elasticity decreased compared with the absolute price case it was about 0.019 which is very low and implies that the aggregate energy demand is highly inelastic and implies that the aggregate energy demand will decrease by .019 percent if the adjusted energy price index increases by one percent. According to the estimated equations, the aggregate energy demand in the Sudan is a necessary and inelastic for the major consuming sectors. Moreover, the aggregate demand for energy in the Sudan is insensitive to both income and price changes. However, it is more sensitive to income changes than to price changes because the income elasticity exceeds the price elasticity.

Part (2) :-

4.3 Energy Demand and the Trade Model :-

Petroleum Imports under Foreign Exchange Constraints :-

Introduction :

This part focuses on macroeconomics and statistical analysis of part of the aggregate energy demand function, i.e. particularly petroleum demand function under the assumption that it is an imported good or commodity that annually enters the trade balance. An attempt is made to construct an inter linkage between oil imports demand function and trade model. Goldstein and Khan (1985) and Cristian Moran (1989) argued that "Trade models have been important tools in the analysis of policy packages to deal with macroeconomic imbalances, and such models have received prominent attention in the economic literature". They argued that to assess proposed macroeconomic adjustment programmes, policy makers must estimate imports demand relative to the foreign exchange available, by considering the importance of exports-imports or trade model". (Cristian Moran .The World Bank Economic Review (1989))

In this part two models are presented, which consider both the traditional variables and indicators of import capacity, foreign exchange inflow (receipts) and foreign exchange reserves. The first model assumes that petrol imports price is exogenous, but in the second model petrol import price is endogenous. The two models are estimated using the time series data covering the period (1980-1993). Then comparison between the two models is made to test the hypothesis that the endogenous price assumption (i.e. Model 2) is more relevant for the case of Sudan as a developing country than the exogenous price assumption (i.e. Model 1).

Imports models discussed in this part of the chapter are basically based on theoretical background and the methodological approaches identified by the W.B. and IMF group study of the behaviour of imports demand function for twenty-one developing countries during the period (1970-1983).[17]

Section (1) discusses the theoretical models developed in the present chapter. Section (II) presents and discusses the empirical estimates of both models using time series date. Section III summarises the main results of the two models.

4.3.1TheTheoretical Background and Definition of Imports Models

Two main imports models are discussed. The first model introduces two sets of explanatory variables prices and domestic outputs; and foreign exchange receipts and foreign exchange reserves.The exogenous price model contains traditional model, general exogenous model and Hemphill model as special case.The second imports model assumes that imports volume and relative imports prices are both endogenous variables including two independent structural supply-demand equations.We begin with the definition and identification of the models (including traditional, Hemphill, general exogenous and endogenous) respectively.Then an attempt is made to discuss the results of estimate of each model.

Model (1) A general Imports Model With Exogenous Price Assumption :-

(A) Traditional Model:-

The first imports model presented here assumes that the demand (volume) for petrol imports is similar to normal and ordinary demand function. The traditional model links imports demand to domestic output and relative prices. The model estimates imports demand as a function of

[17] The results discussed by Cristian Moran - The World Bank Economic Review (May 1989) (p. 279 - 294) Vol. (3) No. (2).

relative price and domestic output or (GDP). But omits changes in foreign exchange. The estimated short-run desired imports demand curve is a simple linear function of relative imports price and real GDP.

$$M^d_t = a_0 + a_1 Y_t + a_2 (Pm/P_t)_t$$

where M^d_t is short run desired imports volume at time t, Y_t represents real domestic[1] income (or real GDP), Pm stands for weight price index of petroleum products.[18] And a_0, a_1 and a_2 are parameters or estimated coefficients of the constant term, Y_t and Pm respectively, P_t is (an aggregate) price index of domestic goods (the GDP delfator). $(Pm/P_t)_t$ represents the adjusted weight price index or relative price. The adjusted weight price index or relative price give better results therefore, the model used the relative price $(Pm/P_t)_t$ rather than the absolute price $(Pm)_t$.

The model assumed that the long-run demand function is given by:

$$M^d_t = d_0 + d_1 Y_t + d_2 (Pm/P_t)_t + d_3 m_{t-1}$$

Where m_{t-1} represents the lagged imports volume.

(B) Imports Under Foreign Exchange Constraints :-

According to Cristian Moran (1989), "For most developing countries the availability of foreign exchange declined in the early of 1980s as foreign lending cut backs, interest rate increased and declined commodities prices forced them to make significant macroeconomics adjustment. As consequence, merchandise import volumes for all non oil exporting countries remained stagnant from 1981 to 1986, compared with annual increase of more than six percent from 1965 to 1981". Moran (1989), argued that in the 1980s, imports in the developing countries have been constrained by the shortage of foreign exchange, governmental policies in response to these shortage has included changes in the

[18] According to The Word Bank Model Pm represents the level of import (e.g.petrol) price i.e. price index which include domestic taxes that reflects tariff and nontariff barriers.

exchange rate and the imposition of tariffs and other barriers that affect the domestic price of imports and thus also affect imports demand. These factors according to Moran (1989), et al, should be incorporated in models developed to estimate the level of imports demand. (Cristian Moran. The World Bank Economic Review (1989))

The imports models received prominent attention in the literature on economic theory and policy analysis. According to Cristian Moran(1989), "The approach suggested by Hemphill (1979) and extended later by Chu, Hwa, and Krishnamutry (1983), Winters and Yu (1985), and Sundararajan (1986) seems to be well grounded in the literature. (Cristian Moran. The World Bank Economic Review. (1989))

The Traditional imports model considers only the traditional variables, including relative price and domestic income with exogenous price assumption. Hemphill (1979), considers the importance of foreign exchange constraint in the determination of imports model but ignores the importance of traditional variables, the model considered as especial case or equation of general exogenous price model. The general endogenous price model considers the foreign exchange constraints and avoid biases due to omission of relevant variables or due to simultaneity of imports volume and imports price. (Cristian Moran. The World Bank Economic Review. (1989)).

There is an argument that, "traditional imports models seem to be more appropriate for the industrial countries which are unconstrained by the availability of foreign exchange receipts. But for most developing countries, particularly oil-importing developing countries (like Sudan)the model is irrelevant because it failed to explain the recent slump in the imports of developing countries which is subject to shortage in foreign exchange receipts". (The Cristian Moran. World Bank Economic Review. (1989)).

(C) Hemphill Model:-

The model considers the importance of foreign exchange constraint in the determination of imports demand function. Hemphill (1979), assumed that imports demand is linearly related to the level of foreign exchange receipts and international reserves. "The model is characterised by the features that only financial variables explain imports functions, i.e. imports volume depends only on financial variables, and the traditional relative price and domestic income are excluded. Hemphill assumed that a country has an exogenously given flow of foreign exchange earning in each year F_t, and that this flow must be allocated between expenditures on imports M_t and (saving) additional reserves $(dR)_t$. He started with the balance of payment identity that

$$F_t = M_t + (dR)_t$$

Where F_t represents exogenous net foreign exchange receipts at time t, M_t stands for total imports expenditures at time t and $(dR)_t$ represents the stock of foreign assets (reserves)". (L.Alan.Winters W.B. (1985) .PP.6-7, 77-78) .

Thus Hemphill estimated equation is given by:-

$$M_t = d_0 + d_1 F_t + d_2 R_{t-1} + d_3 m_{t-1} + U_t$$

Where m_{t-1} stands for lagged volume of total imports, R_{t-1} represents the lagged end year's period of foreign exchange reserves.

In the short run, the model assumed that, change in the stock of foreign exchange reserves is linearly related to foreign exchange receipts, and volume of imports i.e. $dR_t = F_t - M_t$. However, in the long run the model assumed that, foreign exchange reserves is assumed to be positively related to the long run level of imports .i.e.

$R^*_t = z_0 + z_1 M^*_t$, $0 \leq z_1 \leq 1$

Where R^*_t and M^*_t represents long run values of foreign reserves and imports volume respectively. The model assumed that, the long run foreign exchange receipts is linearly related to the current level of foreign exchange receipts i.e.

$F^*_t = F_t + \lambda \, d F_t = (1 + \lambda) F_t - \lambda F_{t-1}$

Cristian (1989), empirical estimation found that $\lambda = 0$ and thus $F^*_t = F_t$ i.e. current level of foreign exchange taken as a proxy for the long run level.

Thus Hemphill's general equation is given by:

$M_t = d_0 + d_1 F_t + d_2 R_{t-1} + d_3 m_{t-1} + U_t$.

Sundararajan (1986) followed Hemphill's assumption, he assumed that imports equation can be derived by minimizing the quadratic cost function used by Hemphill, i.e.

$C_t = B_1 (M_t - M^*_t)^2 + B_2 (R_t - R^*_t)^2 + B_3 (M_t - M_{t-1})^2 + B_4 (M_t - M^d_t)^2$

Subject to the constraints imposed by available foreign exchange, i.e. $dR_t = F_t - M_t$ where C_t represents cost function at time t, M_t is the actual volume of imports at time t, M^*_t is the long run imports volume, R_t, R^*_t are the current and long run level of real foreign exchange reserves respectively, M^d_t represents the short run or desired level of imports volume, Bs are all expected to be positive. Sundararajan (1986) estimated equation represents a general exogenous price equation given below :

$M_t = b_0 + b_1 F_t + b_2 R_{t-1} + b_3 m_{t-1} + b_4 (Pm/P_t)_t + b_5 Y_t$

The equation includes both the traditional and financial variables but considers the latter as only exogenous variable.

Model (2):- A general Imports Model With Endogenous Price Assumption :-

The second model assumed that imports volume and relative imports price are both endogenous to import decision making. Moran (1989), et al, considered Hemphill (1979) equation to determine imports supply or imports capacity given the foreign exchange constraints, the model assumed that imports price and aggregate output do not appear explicitly in this equation, but they still influence imports volume through their effects on the imports demand curve. The complete model contains two independent structural equations, an imports supply which is inelastic with respect to price and a normal downward sloping demand curve.

Thus the endogenous price model equation are given by[19]:-

Demand curve : $\ln M^d_t = a_0 + a_1 \ln (Pm/P_t)_t + a_2 \ln Y_t + a_3 \ln m_{t-1} + U_t$

Supply curve : $\ln M^s_t = b_0 + b_1 \ln F_t + b_2 \ln R_{t-1} + b_3 \ln m_{t-1} + V_t$

For the case of petrol imports in the Sudan the model is given by:-

Demand curve: $\ln M^d_t = a_0 + a_1 \ln (Pm/P_t)_t + a_2 \ln (GDP)_t + a_3 \ln m_{t-1} + U_t$

Supply curve: $\ln M^s_t = b_0 + b_1 \ln F_t + b_2 \ln R_{t-1} + b_3 \ln m_{t-1} + b_4 \ln (Pm/P_t)_t + V_t$

where $M^s_t = M^d_t = M_t$ in equilibrium, and $(Pm/p_t)_t$ are the endogenous variables. According to Moran (1989) model the demand and supply shocks U_t and V_t are assumed to be normally distributed random variables, but may be contemporaneously correlated. This latter assumption has important implications for the interpretation of the model, because it implies that, imports volume and imports price are determined

[19] For the case of Sudan, the present study used end years lagged adjusted foreign exchange reserves (i.e. adjusted by GDP defletor), adjusted foreign exchange receipts which includes total exports + capital inflows and net transfers. Moreover, GDP represents income factor, (relative) adjusted weight average price index of petroleum products and the volume of petrol imports (under the assumption that M_t represents real value) (as dependent variable).

simultaneously with both the supply and demand equations playing important roles in the determination of the two endogenous variables. In the model all the structural parameters (a_i, b_i, i = 1,2,3) are identified, can be easily estimated. The import supply equation, according to Moran (1989) can be directly estimated by using ordinary least squares techniques to yield a consistent and efficient estimate. But imports demand equation cannot be estimated by ordinary least squares technique, because this will yield a biased and inconsistent estimate of the relevant elasticities, because (Pm/p_t) is endogenous and hence correlated with the demand shock U_t, consistent estimates of the demand elasticities can be obtained by using a simultaneous-equation procedure, particularly, the two-stage least squares (2SLS) model.

4.3.2 The Estimation of the Models :-

The demand for petrol imports was estimated for the case of Sudan depending on the available time series data and information obtained from the Bank of Sudan annual reports, Ministry of Energy and Mining statistical publications, and financial information obtained from IMF (Financial Statistical Year Book), the estimated imports model used time series data for the period (1980-1993). Due to changes and variation in economic policy throughout the period (1980-1993), particularly between 1990 and 1993, attempts were made to separate and estimate two time periods i.e. (1980-1990) and (1990-1993), but the presence of acute multicollinearity and appearance of some or a considerable degree of serial correlation in the estimated residuals, create major difficulties for undertaking two separate periods, particularly for the period (1990-1993). The application of these data to the "SPSS for windows" computer programme have the result that, the statistical influences cannot be estimated due to singular variance-covariance matrix. For these major difficulties, the present study takes the over all period (1980-1993), despite the fact that economic policy has changed particularly after 1992.

The Results of the Estimated Models :-

4.3.2.1 Petrol Imports Demand with Exogenous Price Assumption

Model (1) :-

Under the exogenous price assumption without considering the foreign exchange constraint, two results are obtained from two models, traditional and general exogenous models.

(A) The Estimation of Traditional Model:

For the traditional model which ignores the role of foreign exchange constraint in the determination of imports model and considers only the traditional factors like price and domestic income or GDP and without considering the lagged variable (m_{t-1}), the estimated equation for the case of Sudan is given below:-

$$\text{Ln } M_t^d = 12.074 + .2165 \text{ Ln } (GDP)_t - 0.3401 \text{ Ln } (Pm/P_t)_t + U_t$$

t= (1980-1993) (4.607) (.746) (-1.515)

$R^2 = 0.19303$, F = 1.43521, D.w = 2.4417 →eq. (4.2.1).

The W.B. and IMF estimated equation for (21-LDCs) Low income countries during (1970-1983) is given below :-

$$\text{Ln } M_t^d = 0.52 + 0.66 \text{ Ln } m_{t-1} + 0.24 \text{ Ln } Y_t - 0.08 \text{ Ln } (Pm/p_t)_t$$

t= (1970-1983) (0.45) (5.96) (1.58) (-0.78)

The W.B and IMF estimated equation for all the developing countries during (1970-1983) is given below :-

$$\text{Ln } M_t^d = 0.18 + 0.56 \text{ Ln } m_{t-1} + 0.37 \text{ Ln } Y_t - 0.23 \text{ Ln } (Pm/p_t)_t$$

t= (1970-1983) (0.31) (11.23) (5.50) (-4.96)

The estimated traditional equation including m_{t-1} for the case of Sudan during (1980-1993) is given by the following equation :-

$$Ln\,M_t^d = 18.41 + .013\,Ln\,(GDP)_t - 0.37\,Ln\,(Pm/P_t)_t - 0.33\,Ln\,m_{t-1} + U_t$$

t=(1980-1993) (-0.278) (.037) (-1.625) (-1.01)

$R^2 = 0.26147$, F = 1.29813, D.w = 1.88966 →eq. (4.2.2)

The results from the estimated equations (traditional exogenous price model) for the case of Sudan (equation 4.2.1 and 4.2.2) during the period (1980-1993), revealed that petroleum imports demand function is consistent with theoretical predictions (i.e. normal downward sloping demand curve), the estimated coefficients have a correct sign, but most estimated coefficients are statistically insignificant under the 5% level of significance. In both estimated equation 'the goodness of fit' measure R^2 is very low and, and implies that the variables $(GDP)_t$ and $(Pm/P_t)_t$ in equation (4.2.1) and the variables $(GDP)_t$, $(Pm/P_t)_t$ and m_{t-1} in equation (4.2.2) explain only 0.19303 and .26147 percent of the variation in the volume of petrol imports demand in equation (4.2.1) and(4.2.2) respectively. The 'F' statistic in both estimated equations is very low and implies that the overall model is statistically insignificant. The D.w statistics in the first estimated equation suggests the presence of negative serial correlation, but for the second estimated equations suggests the presence of positive serial correlation in the estimated residuals. The addition of lagged variable (m_{t-1}) reduces the correlation problem by a considerable percentage, and the problem mimimized to the extent that the D.w statistic become close to '2'. Although the two estimated equations are statistically insignificant, however, the second estimated equation which includes the lagged volume of petrol imports give a relatively better results compared with the case that neglect the lagged variable.

According to the last estimated equation (4.2.2), the aggregate imports demand for petrol by all sectors in the economy will decrease by 0.37

percent if petrol adjusted weight price index increases by one percent, this implies that the constant price elasticity of petrol imports was about 0.37 which is less than unity, therefore petrol imports have inelastic demand. On the other hand, the income elasticity was about .013 is relatively low and less than unity, implies that petrol is a necessary good or commodity, the income elasticity implies that the demand for petrol will increase by about .013 percent if the GDP increases by one percent.

(B) The Estimation of General Exogenous Price Petrol Imports Demand Function :-

The estimated equation contains five independent explanatory variables i.e. including the financial variables (F_t and R_{t-1}) and the traditional variables. The estimated general exogenous price equation for the case of Sudan (1980-1993) is given below:

$$\text{Ln } M_t^d = -4.826 + 1.44 \text{ Ln}(GDP)_t + 0.7099 \text{ Ln } F_t - 0.577 \text{ Ln}(Pm/P_t)_t$$

t=(1980-1993) (-.519) (2.68) (2.592) (-2.738)

$$- 0.529 \text{ Ln } R_{t-1} + 0.329 \text{ Ln } m_{t-1} + U_t$$

(-1.909) (.945) → equation (4.2.3)

$R^2 = 0.69068$, $F = 3.12604$, $D.w = 2.56050$

The W.B. and IMF estimated equation for (21-LDCs) Low income countries during (1970-1983) is given below :-

$$\text{Ln } M_t^d = -0.64 + 0.62 \text{ Ln } F_t + 0.05 \text{ Ln } R_{t-1} + 0.25 \text{ Ln } m_{t-1}$$

t=(1970-1983) (-0.93) (8.21) (2.24) (3.43)

$$+ 0.17 \text{ Ln } Y_t - 0.03 \text{ Ln } (Pm/p_t)_t$$

(1.63) (-0.43)

The W. B. and IMF estimated equation for all the developing countries during (1970s-1983) is given by the following equation :-

$$\text{Ln } M_t^d = -0.89 + 0.45 \text{ Ln } F_t + 0.05 \text{ Ln } R_{t-1} + 0.34 \text{ Ln } m_{t-1}$$

t = (1970-1983) (-2.43) (16.28) (5.70) (9.78)

$$+ \ 0.24 \text{ Ln } Y_t \ - 0.06 \text{ Ln } (Pm/P_t)_t$$
$$(5.23) \qquad\qquad (-1.80)$$

The results from the estimated general exogenous price model (equation 4.2.3). for the case of Sudan during (1980-1993) demonstrated that, the demand for petrol imports increases with the increase of GDP and foreign exchange receipts, but decreases with the increase of petrol adjusted weight price index and the foreign exchange reserves (i.e. the general exogenous price function is consistent with the theoretical predictions). Most of estimated coefficients are statistically insignificant under the 5% level of significance .Moreover, 'the goodness of fit measure' 'R^2' revealed that the variables $(GDP)_t$, F_t, R_{t-1}, $(Pm/P_t)_t$ and m_{t-1} explain about 0.69068 percent of the variation in the volume of petrol imports. The 'F' statistics is very low and statistically insignificant under the 5% level of significance, and therefore implies that the general exogenous price model statistically insignificant under the 5% level of significance. Moreover, the D.w statistic, suggested that there is some negative serial correlation in the estimated residuals.

According to the estimated equation (4.2.3) the demand for petrol imports will increase by 1.44 percent and 0.7099 percent if the GDP and foreign exchange receipts increases by one percent respectively . But the demand will decrease by 0.577 percent and 0.529 percent if the adjusted weight price index of petrol and foreign exchange reserves increases by one percentage respectively. Petrol imports income elasticity estimated to be 1.44 exceeds unity, implies that petrol is a luxury good or commodity in Sudan.A one percentage increase in GDP will result in 1.44 percent increase in the demand or the volume of petrol imports .On the other side,the price elasticity was about 0.577, less than unity implies that petrol is inelastic good or commodity in the Sudan and petrol demand will decrease by 0.577 percent if the adjusted petrol price index increases by one percent. On the other hand, demand for petrol imports will increase by 0.7099 percent if the foreign exchange receipts increases by one percent.

The results from the estimated equations under the exogenous price model which include traditional, Hemphill and general exogenous price models revealed that the overall model are statistically insignificant under the 5% level of significance, because the 'F' statistic in all these estimated equation is very low, moreover, most estimated coefficients are also statistically insignificant under the 5% level of significance. Therefore, the exogenous price models including traditional, Hemphil and general exogenous price are irrelevant to explain the behaviour of petrol imports demand function in the Sudan during the period (1980-1993). These results are consistent with the IMF and W. B empirical foundation or studies in "21" developing countries which examined the behaviour of imports demand function under the foreign exchange constraint during the period (1970-1983).

(C) The Estimation of Hemphill Model:-

Hemphill model considers only financial variables including foreign exchange receipts and foreign exchange reserve, but neglects the traditional variables.

The estimated Hemphill equation for the case of Sudan during the period (1980-1993) is given below :

$$Ln\ M_t = 16.677 + 0.257\ Ln\ F_t - 0.269\ Ln\ R_{t-1} - 0.285\ Ln\ m_{t-1} + U_t$$

t= (1980-1993) (3.197) (.843) (-.748) (-.836)

$R^2 = .19456$, $F = .72468$, $D.w = 1.71536$ →equation (4.2.4)

For W. B. and IMF (21 LDCs) low income countries during the period (1970-1983) the estimated equation is given by the following equation :

$$Ln\, M_t \;=\; 0.13 + 0.68\, Ln\, F_t + 0.03\, Ln\, R_{t-1} + 0.29\, Ln\, m_{t-1}$$

t =(1970-1983) (0.27) (9.71) (1.37) (4.01).

The W.B and IMF estimated equation for all the developing countries during the period (1970-1983) is given by the following equation:

$$Ln\, M_t \;=\; 0.42 + 0.47\, Ln\, F_t + 0.04\, Ln\, R_{t-1} + 0.45\, m_{t-1}$$

t= (1970-1983) (1.51) (16.91) (4.25) (14.73)

The results from the estimated equation (4.2.4) for the case of Sudan during the period (1980-1993) considering only the effects of financial variables, statistically insignificant under the 5% level of significance, all the estimated parameters expect the constant term are statistically insignificant. The overall significance of the model also is very low. 'The goodness of fit measures' 'R^2' is very low and implies that the variables F_t, R_{t-1} and m_{t-1} in the estimated equation (4.2.4) explain only 0.19456 percent of the variation in the volume of petrol imports. The 'F' statistic is very low and suggested that the model is statistically insignificant under the 5% level of significance. Moreover, D.w statistic approached '2' and implies that there is very low level of positive serial correlation in the estimated residuals.

According to the estimated equation (4.2.4) the imports volume will increase by 0.257 percent if the foreign exchange receipts increases by one percent. On the other hand, imports volume will decrease by about 0.269 percent if the foreign exchange reserves increases by one percent i.e. for the estimated equation the volume of petrol imports increases with the increase of foreign exchange receipts, but decreases with the increase of foreign exchange reserves (because according to Hemphill's assumption $DR_t = F_t - M_t$ or $M_t = F_t - DR_t$ i.e. imports volume is positively related to changes in foreign exchange receipts, but negatively related to changes in foreign exchange reserves, because foreign exchange receipts must be allocated to minimize the differences between expenditures on imports and (saving), net reserve).

In the estimated equation the constant elasticities of foreign exchange receipts and foreign exchange reserves with respect to the volume of petrol imports are very low and less than unity, and the elasticity of foreign exchange reserve exceeds the elasticity of foreign exchange receipts. Thus petrol imports volume is inelastic with respect to foreign exchange receipts and foreign exchange reserve. The result from the estimated equation revealed that imports volume is insensitive to changes in foreign exchange receipts and foreign exchange reserves. However, the results from these estimated equation are statistically insignificant, and therefore Hemphill model which assumed that imports volume is only determined by financial variables is irrelevant for the condition of Sudan during the period (1980-1993). These results are consistent with the W. B. and IMF studies during the period (1970-1983). The results of the exogenous price models including the traditional model, general exogenous model and Hemphill model are statistically insignificant under 5% level of significance and therefore these models are irrelevant to explain the behaviour of petrol imports demand function in the Sudan during the period (1980-1993). These results are consistent with the W. B. and IMF empirical foundation to study the behaviour of imports demand function under the foreign exchange constraint in "21" developing countries during the period (1970-1983).

4.3.2.2 Petrol Imports Demand Under The Endogenous Price Assumption:

Model (2) The Estimation Of Petrol Imports Demand Under Foreign Exchange Constraint (Endogenous Price Assumption) :-

According to Cristian Moran (1989), the model is more relevant to the developing countries, because the model considers the importance of financial foreign exchange reserves and foreign exchange receipts in the determination of the volume of oil imports, beside the traditional variables like (relative) adjusted petrol price index and the real domestic income (GDP). With the endogenous price assumption the simultaneous equations technique (supply-demand equation) is used to estimate petrol imports demand function. The ordinary least squares technique will give a biased and inconsistent estimated therefore the two-stage least squares model is used to estimate the demand function which is over identified equation. The model considers three endogenous variables (demand, supply and price).

The estimated equation of petrol imports with the general endogenous price assumption for the case of Sudan during the period (1980-1993) is given below:

$Ln\,M_t = 17.485 + 0.04\,Ln\,(GDP)_t - 0.07\,Ln(Pm/P_t)_t - 0.30\,Ln\,m_{t-1}$

t= (1980-1993) (13.088) (.59) (-1.409) (-4.686)

$R^2 = 0.81034$, $F = 12.81765$, $D.w = 1.08586$. →eq. (4.2.5)

The W. B. and IMF estimated equation for "21" low income countries during the period (1970-1983) is given below :

$Ln\,M_t = -3.25 + 0.49\,Ln\,m_{t-1} + 0.86\,Ln\,Y_t - 0.64\,Ln\,(Pm/P_t)_t$

t= (1970-1983) (-1.05) (2.62) (1.75) (-1.50)

The W. B. and IMF estimated equation for all the developing countries during (1970-1983) is given by the following equation :

$$\text{Ln } M_t = -12.48 - 0.09 \text{ Ln } m_{t-1} + 2.18 \text{ Ln } Y_t - 2.01 \text{ Ln } (Pm/P_t)_t$$

t= (1970-1983) (-3.98) (-0.48) (5.03) (-4.93).

The results from the estimated equation (4.2.5), for the case of Sudan during the period (1980-1993) with the endogenous price assumption demonstrated that petrol imports demand function is consistent with the theoretical predictions (i.e. normal downward sloping demand curve) that demand for petrol imports increases with the increase of GDP, but decreases with the increase of adjusted (relative) weight petrol price . All the estimated coefficients have their expected signs (i.e. correct signs). The constant term and lagged volume of petrol imports (m_{t-1}) coefficients are statistically significant, but the GDP and price coefficients are statistically insignificant under the 5% level of significance. The 'F' statistic is very high and therefore suggested that the overall model is statistically significance under the 5% level of significance. The D.w statistic suggested that there is a considerable positive serial correlation in the estimated residuals. 'The goodness of fit measure' R^2 is very high and indicates that the variable GDP_t ,$(Pm/P_t)_t$ and m_{t-1} explain about 0.81034 percent of the variation in the volume of petrol imports demand.

According to the estimated equation (4.2.5) the constant income elasticity is less than unity and implies that petrol is a necessary imported good or commodity in the Sudan. The constant income elasticity was about 0.04, means that petrol imports demand will increase by 0.04 percent if GDP increases by one percent. On the other side, the constant price elasticity is less than unity implies that petrol imports have inelastic demand in the Sudan. The estimated constant price elasticity was about 0.07 means that, petrol imports demand will decrease by 0.07 percent if adjusted (relative) weight petrol price increases by one percent.

The results from all these estimated equations revealed that the endogenous price model gives better results compared with the traditional and general exogenous price models, because the endogenous price model is statistically highly significant compared to the exogenous price models. The overall significance measured by the 'F' statistic in the endogenous price model is statistically significant, while all the exogenous price models (traditional, Hemphill, and general exogenous models) are statistically insignificant because the overall significance of the model as measured by the 'F' statistic is very low and insignificant compared with the 'F' statistic in the endogenous price model. Moreover, 'the goodness of fit measure' 'R^2' with endogenous price assumption is high compared with exogenous price assumption, i.e. the explanatory power in the endogenous price model is better than in the exogenous price models. Moreover, most coefficients in the exogenous price model are statistically insignificant under the 5% level of significance. In the endogenous price model the price and the income coefficients are insignificant, while the constant term and the lagged volume of petrol imports coefficients are statistically significant under the 5% level of significance. Thus the endogenous price model which considers the importance of foreign exchange constraint in the determination of the volume of petrol imports is statistically more significant and acceptable, and therefore more suitable and relevant for the explanation of the behaviour of petrol imports demand function in the Sudan.

The results from the estimated equations revealed that, the D.w statistic suggested a very high level of serial correlation in the estimated residuals (except general exogenous traditional model with lagged imports volume and Hemphill model), this implies that petrol imports volume and petrol imports price are determined simultaneously, with both the supply and demand equations playing important roles in the determination of the two endogenous variables.[20]

4.4 Conclusion :

4.4.1 Conclusion Part (1) :

This part of the chapter focused on micro and macro statistical analysis of energy demand function in the Sudan using the ordinary least squares model and the double Logarithmic (or natural Logarithmic) demand equation. The part identified the sectoral equations at both micro and macro level for the three sources of energy used in the Sudan (Biomass, electricity and petroleum products). All the estimated equations showed a price elasticity less than unity, and in most cases the income elasticities are less than unity, this implies that most energy types have inelastic demand and are necessary for the consuming sectors in the Sudan. In most cases the income elasticities exceed the price elasticities, this implies that, demand functions are more sensitive to income changes than to price change and therefore, a one percentage change in income is more effective in changing the behaviour of energy demand functions than a one percentage change in the price.

Most estimated equations are statistically significant, some results are statistically insignificant, but the estimated coefficients give the expected results (i.e. have a correct sign), these include total energy demand (e.q. (2) and commercial sector demand for electricity eq.(1), household demand for biomass (lagged demand e.q.(2)), household demand for electricity and aggregate demand for petroleum products).On the other hand, some results are statistically significant but the estimated coefficients did not give the expected results (i.e. have a wrong sign) (e.g.

[20] See page (284). A General Import Model with Endogenous prices by Cristian Moran. The World Bank Economic Review Vol. (3) No. (2) May (1989).

the price coefficient is positive in some estimated equations, this include household demand for biomass e.q.(1), total energy demand equation e.q.(1), benzine demand e.q.(2) and (3) and gasoil demand by transport sector equation e.q.(2). The positive price coefficient in these estimated equations violated the assumption of downward sloping demand curve and produced upward sloping demand curve, these attributed to price distortion and subsidization policies during the study period. The income coefficients and the income elasticities in all the estimated equation are positive and produce a normal demand curve. In most estimated equations the results of relative price (i.e. the adjusted price (i.e. adjusted price by GDP deflator or CPI) are statistically better and more significant than the results of the absolute price.

4.4.2 Conclusion Part (2) :-

This part of the chapter concentrated on demand for petrol as imported commodity, statistical analysis used to test the hypothesis that petrol imports demand function in the Sudan is endogenously determined by the availability of foreign exchange receipts, or the adjusted petrol price index is an endogenous variable in the determination of the volume of petrol imports demand . Two (hypothesis) models are discussed the exogenous price model (which include traditional, general and Hemphill models) and the endogenous price (simultaneous, supply-demand) equations are estimated. Traditional model assumed that price is an exogenous variable in petrol imports demand function and imports demand function is determined by the traditional variables (Y,P), Hemphill model assumed that imports demand function is only determined by the financial variables rather than the traditional variables (income and relative price). The results from the estimated exogenous price models are statistically insignificant for the case of Sudan during the period (1980-1993), these results are consistent with the World Bank and the IMF studies in '21' developing countries including Sudan during the period (1970-1983). The results from these studies support the claim that the exogenous price model is not useful or fail to explain the behaviour of imports demand function in the developing countries including Sudan. On the other hand, the results from the estimated equations under the endogenous price assumption are statistically highly significant compared with the exogenous price model. These results verified or supported the argument that imports demand function in the developing countries including Sudan is endogenously determined by the availability of foreign exchange receipts. Therefore, petrol imports demand function during the period (1980-1993), is endogenously determined by or constrained by the availability of foreign exchange receipts. Thus the endogenous price assumption or model compared with the exogenous price model, is statistically more acceptable and relevant to explain the behaviour of petrol imports demand function in the Sudan during the period (1980-1993).

4.4.3 Conclusion of the chapter

This chapter focused on micro and macro statistical analysis of energy demand function in the Sudan. The chapter concentrated on demand side, because the nature of energy problem in the Sudan is (greatly) significantly attributed to the excess demand problem. The first part of the chapter estimated the sectoral and aggregate demand functions, using the natural double logarithmic demand model to examine and analyse the behaviour of energy demand function in the Sudan. All the estimated equations at the sectoral (micro-level) and aggregate (macro-level) revealed inelastic demand functions with respect to prices. In most estimated equations, the quantity demanded is more sensitive to income changes than to price changes. Most estimated equations are statistically significant and most estimated coefficients have their expected signs (correct sign) or results which are consistent with the assumption of a normal downward sloping demand curve. For some results the coefficients have correct signs but the results are statistically insignificant (total energy equation (2) and commercial sector demand for electricity e.q.(1) total demand for petroleum products, household demand for electricity and biomass e.q.(2)). Some results are statistically significant but the estimated coefficient have a wrong sign (household demand for biomass e.q.(1) and total energy demand eq. (1), benzine eq. (2) and (3) and gasoil demand by transport sector eq. (2)). These functions violated the downward sloping demand due to price distortion and subsidization policies during the study period and because prices did not reflect the real costs. In most estimated equations the income elasticity is less than unity, therefore energy is a necessary good or commodity for consuming sectors in the Sudan. Demand curve is normal curve because the income elasticity is positive

The second part of the chapter concentrated on energy demand and trade model i.e. petrol imports demand function (using the W. B. and the IMF models and assumptions during the period (1970-1983) in Sudan during the period (1980-1993). Two hypothesis are tested using two models, the exogenous price model and the endogenous price model. The results of the second part verified that the exogenous price model fail or irrelevant to explain the behaviour of petrol imports demand function because the results are statistically insignificant. The results of the second part supported the claim that imports demand function in the Sudan is significantly determined or constrained by the availability of foreign exchange receipts, because the estimated endogenous price equation is statistically highly significant under the 5% level of significance compared with the exogenous price model. Thus in the Sudan, endogenous price model is more relevant to explain the behaviour of petrol imports demand function than the exogenous price model.

CHAPTER FIVE
THE ECONOMICS OF ENERGY IN THE SUDAN

Chapter Five

The Economics of Energy in the Sudan

Introduction:

For a developing country like Sudan, energy fuel is an indispensable element for the process of economic development. The results of the estimated energy demand function in chapter (4) strongly emphasized or revealed the fact that energy demand is price inelastic, mainly because of the lack of close substitutes in the short or medium terms, in addition to this, "energy is irreplaceable element for final consumers (e.g. demand for household cooking, heating, transportation and lighting), moreover, energy is a key factor without which the production process cannot operate adequately effectively, or in a perfect way, infact energy fuel are indispensable for modern industry and agriculture and added as a fourth factor of production".(Michael Tanzer (1969) pp.3-4).

The present chapter examines the interrelationship between the energy sector and the other productive sectors in the economy. This will be achieved through the identification of sectoral consumption. The chapter focuses on oil products because the performance of the productive sectors is largely affected by them. Thus the first section focuses on regional - sectoral consumption of oil by type for the period (1980-1993). The second part of the present chapter examines the impacts of oil as a basic source of commercial energy and as imported commodity on the performance of the economy, through the identification of their effects on Balance of Payments, Balance of Trade Deficit and Balance Budget Deficit, their impacts on inflation and GDP growth rate. The present chapter also discusses briefly the impacts of energy supply shortage on the over all sectoral performance of Sudan's economy.

5.1. The Importance Of Oil Products to Sudan's Economy :-

5.1.1. Introduction:

Oil products play an important role in overall economy, in fact "No commodity plays a more vital role than oil in the economic life of the underdeveloped countries of the world. Obviously for nations with enormous oil deposits such as Venezuela, part of the Middle East and North Africa. Oil is the economic life, oil exports provide not only a large share of national income, but also most of these countries foreign exchange earnings. Oil thus represents the great assets which could potentially provide all the capital necessary for economic development" (Michael Tanzer (1969) p. 3).

In fact oil and its components are occupying special place in the 'World Energy Balance'. Recently their role continuously increased, because they are the major energy sources for their direct effects in the agricultural, industrial sectors and even social life of all population in the world. They represent a source of primary raw materials and basic intermediary inputs in the agricultural and industrial and chemical process. Today oil and its components contribute or enter in the production of more than 300,000 commodities.(The Impacts of Oil Revenues on National Developments -The Second National Economic Conference. 1984. P.2))

5.1.2 The Regional and Sectoral Consumption of Oil Products (1980-1993) :-

The understanding of the impact and importance of oil in any economy, necessitates an adequate discussion of consumption pattern, this includes consumption by type, regional and sectoral consumption.[21] (Table (5.1), (5.2) and fig.(5-1), (5-2))

5.1.2 (A) The regional consumption:-

Regional consumption of energy sources varies across the country according to the availability of energy sources, economic needs and the pattern of economic activities prevailing in each region. For example, Kordofan, Darfur and Southern regions mainly depend on traditional energy sources (fuel wood and charcoal), this is partly attributed to the lack of commercial energy resources because these regions are far from the reach of commercial energy and partly due to the dominance of traditional economic activities which have little reliance upon commercial source of energy. In the other regions like Khartoum, Central, Eastern and Northern regions, commercial energy is largely used particularly oil products like gasoil, furnace, benzine and diesel. This could be attributed to the existence of more productive enterprises and concentration of thermal units and due to higher concentration of urban population (Energy Hand Book 1987, 1990 and 1991).

Table 5.1 (a): Regional Energy Consumption (1984)

Region % years	Khartoum	Central	Eastern	Darfur	Kordofan	Northern	Southern
1984	38.8%	23.3%	22.2%	1.8%	3.2%	8.8%	1.9%
(B) Regional consumption of oil products (1986-1987)							
1986	44.7%	20.9%	1.4%	3.1%	8.6%	20.2%	11.0%
1987	40%	24%	2.1%	3.8%	9.2%	20.4%	.8%

Source: Energy Hand Books (1987, 1990)

According to table (5.1.(a) and (b)) Khartoum has the highest share of energy consumption followed by the Central and Eastern regions

[21] All Information and figures in this section, depend on statistical information prepared by the Ministry of Energy and Mining (see Energy Hand Books 1987, 1990 and 1991).

respectively, due to concentration of urban population and productive enterprises. Khartoum also has the highest consumption of oil products particularly gasoil, furnace, benzine and L.P.G. compared with the other regions. Table (5.1.c) show the regional consumption of oil products in 1990.

Table 5.1.(c): The Regional Consumption of Oil Products by Type (1990)

Region/Type	Khartoum	Eastern	Central	Northern
Gasoil	33%	26%	22%	9.6 (10%)
Furnace	59%	13%	20.9%	5.6
Benzine	63%	*	*	*
L.P.G.	78%	*	*	*

Source: Energy Hand Books (1991).

* No information are available

5.1.2 (B) Consumption by Type :-

Throughout the period (1980-1995), gasoil has been the major oil products consumed in the Sudan due to its comprehensive utility and its close substitutability for the other products. During this period total consumption by all sectors has increased from 510553 (MT) in 1980 to 606465 (MT) and 772349 (MT) in 1985 and 1990 respectively, but it declined to 753291 (MT) in 1995. Gasoil product is used in the agricultural, industrial and transport sectors. The increase in gasoil consumption between (1980-1990) could be attributed to the governmental policy of directing gasoil product to enhance and promote the agricultural production in the irrigated schemes in Al Gezira and Al Managil extension and the rainfed schemes in Al Gadarif (Eastern region). The major consuming regions of gasoil are Khartoum, Central and Eastern regions respectively. The fall in gasoil consumption after 1990 to 1995 is mainly due to elimination of the subsidies.

The second major oil products consumed in the Sudan is furnace which is heavily used in the industrial and transport sectors and marginally used in the agricultural sector. Compared with gasoil, the consumption of furnace oil represents or accounts for only half of total gasoil consumption. The validity of the product concentrated mainly in electric power station, industrial and transport sectors. The total consumption of furnace product has changed from 170502 (MT) in 1980 to 266063 (MT), to 254691 (MT) and to 340393 (MT) in the years 1985, 1990 and 1995 respectively. The decline in consumption between (1985-1990) could be attributed to the substitution of furnace product by the other oil products like gasoil, diesel and by bagass (which is widely used as important energy sources in the industrial sugar factories. (Energy Hand Book, 1987 and Petroleum Products Statistical Unit Publications(1990-1996).

Benzine occupies the third place in Sudan's oil products consumption scale, accounting for about two thirds (2/3) of total furnace consumption. The product usage is restricted to transport sector. Khartoum is the largest consuming region of benzine, because of high urban population and high number of vehicles. In 1991, the region consumed about 63% of total benzine consumption in the country, while the other regions (Central, Eastern and Northern) consumed about 37% of benzine consumption in the country. Benzine total consumption has changed from 190951 (MT) in 1980 to 186168 (MT), 234131 (MT) and to 183614 (MT) in the years 1985, 1990 and 1995 respectively.

The rest of oil products consumed in the Sudan accounted for a very low or small percentage of total consumption, these include diesel, kerosene and L.P.G. The consumption of diesel has changed from 20407 (MT) in 1980 to 25243 (MT), 34475 (MT) and 45641 (MT) in the years

1985, 1991 and 1995 respectively. Although diesel accounts for a very limited or small percentage of total consumption. However, the consumption of the product doubled during the period (1980-1995), this could be attributed to the increase of diesel consumption by the agricultural, industrial and transport sectors. In addition to the extension of thermal power station (Energy Hand Book, 1991 and Petroleum Products Statistical Unit Publications(1990-1996)).

Kerosene consumption has changed throughout the period (1980-1995), from 17626 (MT) in 1980 to 12302 (MT), 17241 (MT) and 3760 (MT) in 1985, 1990 and 1995 respectively. Recently a very small proportion used by the industrial sector. Although total kerosene consumption increased during the period (1980-1995), but it is mainly used by the household sector for lighting and cooking purposes and for water pumping in rural areas.

Liquid petroleum gas (L.P.G) is also mainly consumed by the household sector, used in modern gas stoves, its consumption is concentrated mainly in Khartoum which has the highest percentage consumption , compared with the other regions, it accounted for about 80% of total L.P.G. consumption in 1987. Total L.P.G. consumption in the country during (1980-1995) has doubled, there was a continuos increase in the total consumption from 5109 (MT) in 1980 to 7564 (MT), 12849 (MT) and 15197 (MT) in the years 1985, 1990 and 1995 respectively. The increase in total consumption according to Energy Hand Book (1991), was attributed to the improvement of refinery production unit of L.P.G. and due to increase of importation of L.P.G. and its substitutes. Total L.P.G. consumption during(1992-1994) declined due to liberalization policies and the elimination of subsidies.

Jet-AI consumption steadily increased throughout the period (1980-1995), due to the development of air transportation business in the Sudan. The total consumption which was restricted to the air transportation has approximately doubled during (1980-1995), it has increased from 47628 (MT) in 1980 to 79144 (MT) in 1985 but declined to 73735 (MT) in 1990 and increased to 79509 (MT) in 1995. On the other hand, Avagas consumption changed during (1980-1995), its total consumption changed from 6090 (MT) in 1980 to 3676 (MT), 1119 (MT) and 1628 (MT) in the years 1985, 1990 and 1995 respectively.

According to Energy Hand Book (1990) the total consumption by type changed through the period (1980-1989). (Table (5.2) and Figure (5-2.b)). The average percentage of total consumption by type during the period (1980-1995) were as follows, gasoil, accounted for 61.6%, of total consumption, diesel 2.6%, benzine 12.7%, kerosene 1%, furnace 16.9%, L.P.G. 0.6%, Jet-AI 4.4% and Avagas .2% of total consumption by type.

The forecasts prepared by Ministry of Energy and Mining (1996) for the period (1996-2010) Table (5.3), Figure (5.3.b) reveal that the average total consumption of furnace , avagas, kerosene and L.P.G. will increase to 24.2%, 4.2%, 1.9% and 1.2% respectively and the consumption of gasoil, Jet-Al and benzine will decline to 57.1% .1% and 11.4% respectively. These decline attributed to liberalization policies and elimination of subsidies in these two products. The forecasts assume that L.P.G. and kerosene consumption increase because they are used as a substitutes for biomass (charcoal) by the household sector. Furnace consumption expected to increase by the industrial sector, because it will be used as a substitute for biomass. Benzine consumption will increase from 232 (000) (TOE) in 1998 to 253, 323 and 411 (000) (TOE) in the years 2000, 2005, and 2010 respectively. Furnace consumption will increase from 449 in 1998 to 550, 702 and 895 (000) (TOE) in the years 2000 2005 and 2010 respectively. Gasoil consumption will increase from 982 in 1998 to 1145, 1682 and 2472 (000) (TOE) in the years 2000, 2005 and 2010 respectively. Kerosene consumption will increase from 44 in 1998 to 46, 52 and 59 (000) (TOE) in the years 2000, 2005 and 2010 respectively, L.P.G. consumption will increase from 27 in 1998 to 28, 32, 36 (000) (TOE) in the years 2000, 2050 and 2010 respectively. total consumption of avagas and Jet-AI expected to increase during the period (1998-2010) (Table (5.3) and Figure (5-3 a,b)).

5.1.2 (C) The Sectoral Consumption of Oil Products(1980-1995) :-

The sectoral consumption of oil products in the country varies throughout the period (1980-1995), according to the availability of oil products and sectoral needs. The basic consuming sectors are agricultural, industrial, transport, electricity and household sectors.[22] Among these consuming sectors the transport sector ranks on the top accounting for the highest share of oil products consumption, while the household sector has the lowest percentage share of total annual sectoral consumption. (Table 5.1.d and fig. (5.1 (a) and (b)).

(A) The Agricultural Sector :-

The agricultural sector consumption of oil products in the country throughout the period (1980-1995) witnessed a considerable increase mainly due to extension in mechanized agricultural farm, and due to governmental policy which has concentrated on agricultural sector as a leading productive sector in the economy, thus the sector received top priority in the distribution of oil products. The agricultural sector mainly uses gasoil and diesel and recently a small proportion of furnace products.

[22] All Information and figures in this section, depend on statistical information prepared by the Ministry of Energy and Mining (see Energy Hand Books 1987, 1990 and 1991).

Total oil consumption increased from 195071 (MT) in 1990 to 214833 (MT) in 1991 but declined to 156067 and 209261 (MT) in 1992 and1993 respectively, due to liberalization policies.The total consumption jumped to 407335 (MT) in 1994 but declined to 204483 (MT) in 1995, these attributed to expansion in the agricultural sector during (1992/93-1994/95).On average the sector contributed by about 17.5% of total sectoral oil consumption fig.(5.1.b).

(B) The Industrial sector :-

The industrial sector consumes a considerable percentage of total oil products including furnace, diesel, gasoil, and a small proportion of kerosene. During (1980-1995) the industrial sector is the second major oil consuming sector and on average consumed about 22.4% of total oil sectoral consumption fig.(5.1.b) .The total oil consumption increased from 101417.6 (MT) in 1980 to 171017(MT), 661483 (MT) in the years 1985 and 1990 respectively, the total consumption declined to 380172 (MT) in 1991 to 340635 (MT) in 1993 then increased to 509173 (MT) in 1994 but again declined to 382871 (MT) in 1995. The decline from 661483 (MT) in 1990 to 382871 (MT) in 1995 is attributed to liberalization policies and removal of subsidies.

The sugar industry in the Central region, Kenana, Asallaya is the biggest consuming subsector accounted for 50% of total oil products consumed by the industrial sector, it is followed by Food Industries in Khartoum and Central regions which consumed about 20% of total oil products consumed in the industrial sector. Chemical and tyres factories consumed about 16% of total industrial consumption, cement and textile industries consumed about 9% and 8% of the total industrial sector consumption respectively.(Energy Hand Book 1991).

In 1987, the total consumption of the industrial sector declined particularly in sugar and textile subsectors, this was attributed to the failure of agricultural harvest in 1987 and the down ward trend in the productivity of Sudan's textile mills due to technical and administrative difficulties. The rate of decline in sugar subsector was approximately 17%, while in textile subsector was about 25% . On the other hand, food and other industrial subsectors total consumption increased in 1987 relative to 1986, this was attributed to the increase in their productivity, because of the establishment of new factories (Energy Hand Book 1990).

In 1990 the industrial sector consumption declined by about 4% due to a general down ward trend in total productivity of the sector, which was attributed to the lack of hard currency to secure imported inputs and spare parts in the critical (right) times and due to inappropriate infrastructure support, (Energy Hand Book 1990 and 1991).

(C). The Transportation Sector :-

The transport sector is the largest consuming sector of oil products in the Sudan, on average it accounts for about (50% - 57%) of total oil products consumption, during the period (1980-1995) the transport sector on average consumed about 57.9% of total oil sectoral consumption fig.(5.1.b). The sector uses gasoil, furnace, benzine, fuel oil, Jet-AI and avagas. During the 1980s especially in 1983, there was a considerable increase in oil products consumption by the transport sector. This could be attributed to, first the growth of road transportation network in the country, second the governmental policy of subsidization of gasoil price and due to increase of number of imported vehicles using gasoil product, third regonalization policies which has stimulated demand in different regions. Road transportation mode is the biggest consuming subsector, it accounts for 80% of total consumption, followed by air transportation subsector, which accounts for 11% of total consumption, the rest 9% is consumed by river, sea and railway transportation modes . By the end of 1980s, specifically in 1989, the sectoral consumption declined to 55%, this could be attributed to the governmental policy to restrict private vehicles consumption and vehicles import. (Energy Hand Book).And recently after 1992 due to privatization and liberalization policies and elimination of subsidies

(D) The Electricity sector :-

The sector uses mainly gasoil and furnace. During the 1980s, the expansion in thermal power generation led to increase in the consumption of oil products by this sector. In 1983 the electricity sector consumed 10% of total oil products consumption. In 1989 the percentage of total consumption jumped to 14% of total sectoral consumption. This was attributed to extension of thermal units of power III and new additional isolated thermal power station in Nyala, Elobied, Port Sudan, Kassala and Atbara.(Energy Hand Book .1991).

(E) The Household sector :-

The household sector is the lowest consuming sector of oil products. The major products used in this sector are L.P.G and kerosene which are used for cooking and lighting purposes, during (1980-1995) the household sector on average consumed about 2.2% of total oil sectoral consumption fig.(5.1.b). The sectors consumes all L.P.G. product and most kerosene product. In recent time gasoil product is widely used by the household sector in rural areas for lighting and cooking purposes. On average the sector has a fixed percentage, it accounts for 2.5% of total oil products sectoral consumption in the economy.

5.2. Energy Shortage : The Impacts of Inadequate Energy Supply:

Since energy is a key or an indispensable input in almost all economic activities, therefore these economic activities in Sudan have been largely if not almost affected by a shortage or inadequate energy supply. "Past studies or the suppressed demand for petroleum products in Sudan suggested that about 28% of real demand is suppressed; no studies exist in regard to other forms of energy. There is no satisfactory way of quantifying the extent and impacts of energy shortages for two reasons, first the National Income Statistics do not permit sufficient disaggregation by subsectors for recent years. Second, production losses in agriculture and industry are due to many constraints, whose separate effects cannot be disentangled".(UNDP, W. B. Report 1983 p.7).

The National Energy Administration (NEA, 1985) demonstrated that, for the past five years consumers in the Sudan have suffered as the supply of energy has not met their needs and wants. This shortage has disrupted the lives of most people, forced up the cost of living and caused major losses to the economy. In fact energy shortages affect all population in Sudan, because individuals are discomforted by the frequent electricity outages and waste hours waiting in line for fuel. Moreover, productivity is reduced at the work place as a result of such inconveniences. The economic effects are concentrated in the industrial and agricultural sectors, lack of energy resulted in a higher production costs, reduction in output and wasted capital investment. According to the NEA (1985), the situation has deteriorated recently and forecasts indicate that if no changes are made, condition will continue to worsen. (NEA.1985,NEP.1985 pp.1-12 and C.de.Jong-Boon, 1990 pp. 272-273).

According to NEA (NEP-1985) higher cost of production resulted from both an absolute scarcity of energy and unreliable supplies. Because the absolute scarcity limits economic growth, due to reduction in planted and irrigated feddans, factory expansion must be deferred or scrapped, and delay of or cancellation of new projects. These will directly reflect in slower rate of growth of GDP, compared to a situation of adequate energy supply. On the other hand, unreliable supply causes far greater losses to the economy, because huge costs are incurred when people undertake a project or production operations with the expectation of available power, only to find their operations plagued by unplanned electricity shortages and/or anticipated fuel shortage. Moreover, crops and inventory in process are spoiled and production costs increase due to high start up expenses and higher costs of securing back up energy supplies. Additional costs are incurred as equipment are damaged by power surges and outages. Finally, losses also arise from under-utilization of capital due to energy shortages.

In 1983, these losses were quantified for smaller irrigated and mechanized farms in Khartoum and the Central regions. Over all Sudan suffered losses of £S133 million. For smaller irrigated and mechanized farms shortage ranged from 20-40% of required energy. The huge losses in output resulted from lack of fairly inexpensive energy inputs in irrigated electric pump schemes, the lost of output was about 3.54£S per KWH, while the losses of KWH was only 13 pt. similarly for mechanized farming, a loss of 18.5£S was incurred for each in available gallon of gasoil costing about 2.7£S (NEA (1985) and C. de. Jong-Boon, 1990 pp. 277-278).

According to UNDP and W.B. (1983), "the Sudanese economy was characterized by severe shortages in the past few years, which have affected all the economic activity. Allocation of petroleum products to the agricultural and industrial sectors has been inadequate or insufficient in relation to their needs and the problems has been compounded by an inefficient and unreliable public power supply. There were frequent power interruptions, and power supply to industry was curtailed drastically for a two to three months period when hydroelectric generation dropped, the supply of kerosene has also been reduced drastically over the past seven years. With the result that quantities of gasoil, allocated to the other sectors, has been directed to lighting, there was also a growing fuel wood shortages leading to deforestation of large tracts of land in the Northern region".(UNDP, W. B. Report 1983 p.30).

Since agriculture is the leading economic sector in the Sudan, e.g. according to table (3.7) and fig. (3.7), during the period (1980-1993) on average the sector consumed about 3% of total sectoral energy consumption and 98% of this energy consumption was in the form of petroleum products that consumed for water lifting and agricultural operations, so any shortages of oil products will affect the total productivity in the agricultural sector. According to UNDP.W.B. Report (1983), production losses in the agricultural sector were caused by a number of factors, these include delays and inadequacies in land preparation; inadequate rainfall in certain years, shortage of irrigation, unavailability of agricultural equipment for one reason or another and shortage of fertilizers. They claimed that "there was no clear cut way of quantifying the losses due to energy shortage alone, however, it was estimated that interruptions in energy supplies to pumped irrigation schemes at critical times during the last years, caused a production losses of at least US $ 60 million." Agriculture in Sudan is more dependent on commercial energy than in many other developing countries, therefore, lack of timely commercial energy supplies could be responsible for some of the factors listed above. Moreover, energy shortage at the critical and required times lead to delay in planting, harvesting and transportation of crops after harvesting.(U.N.D.P. and W.B.Report 1983).

For example, while output of sorghum was more than doubled in 1982, harvesting of the mechanized farm corporation was delayed due to fuel shortages, and this delayed land preparation for the next season. Losses have also been incurred due to inadequate transport facilities for crops, particularly in the Western region, for example it was reported that about half million ton of sorghum deteriorated due to the lack of transport from the Western region (U.N.D.P. and W.B. Report 1983).

The impacts of energy shortage was not restricted to the agricultural sector, but extended to affect the other productive sectors in the economy. According to UNDP and W.B. (1983) , the total output in the industrial sector was constrained by the shortage of raw materials, energy skilled manpower and spare parts, however, it was again not possible to disentangle the separate effects of these shortages. They demonstrated that, "in most cases, the shortage of raw materials, appeared to be the main products constraints, for example, cotton seed due to drop in cotton production, or imported raw materials, due to shortage of foreign exchange receipts, on the other hand, it was noticeable that there was a marked drop in monthly production during the Summer months (May-July), when the supply from the Blue Nile Grids was restricted. For example, according to their study textile mills experienced a complete power cut between (May-July) in 1982 and thus suffered a production losses despite a stand by capacity of 6.2 MWH as against a requirement of 9 MWH; in addition, frequent power cuts and voltage drops led to equipment damage and hence the need for more spares. According to the NEA studies, there was a markedly low capacity ulitization in Sudanese industry, while capacity utilization in industries operating in Port Sudan area was of order of 65%, in the rest of the country it averaged around 40%, the high capacity utilizatin in the Port Sudan area was mainly attributed to a greater degree of self-reliance in electricity generation and easier access to petroleum supplies from the Port Sudan refinery, imported raw materials, spare parts and other inputs.

Although, currently there are considerable efforts to exploit the existing internal indigenous sources of petroleum products in Sudan, however, the recent discoveries of oil and gas are not likely to have any major impacts in alleviating these energy shortages in the short run, because the productivity is so low and inadequate to alleviate or even minimize the current commercial energy shortages.

According to UNDP and W.B. Report (1983), substantial electric generation capacity is likely to be commissioned in the near future, and the availability of power to industry and agriculture is likely to improve.

If Sudan managed to exploit all the stock of oil discovered or expected to be available, this will create a positive impacts in the economy, according to oil Arab countries experiences. "For oil producing and exporting countries, the advantages of oil sector are many, first oil or petrol sector represents a mean or a source of attracting and saving capital needed or required for investment in development schemes or programmes. This is because in most developing countries capital is the most important constraint or obstacle that hinder development process. In addition to this oil is a source of energy, it represents 90% of consumed energy in oil producing and exporting countries, oil is a basic vehicle of development cycle in the agricultural, industrial and services sectors.Moreover, oil itself represents an industrialized sector, for example in petrol, chemical (or petro-chemical) pesticides industries and other manufacturing, added to all these, oil is an agent factors that helps the Arab countries to co-operate and create, international, political, commercial financial and economic co-operation and integration between Arab countries".(Fraid Omer Madani . 1984 and Mohamed Nory Hamid .1984).

Thus considering these factors, in Sudan oil exploitation become an urgent priority to overcome the current crisis and to move toward sustainable development objectives.

5.3. The Economics of Petroleum in the Sudan:

5.3.1 Introduction

In fact the impacts of oil or petroleum products in Sudan's economy is recognized and could not be marginalized. The understanding of the nature or pattern of these impacts necessitates and requires an adequate knowledge of the structure of Sudan's economy.

In Sudan, as in many other developing countries, the economy is characterized by under-development, low per-capita income and duality in the productive sectors. Moreover, agriculture still is the largest or leading productive sector and on average it accounts for or contributes by 40% of the total National Income or GDP, and absorbs or employees 80% of the total population. Moreover, the economy is characterized by the persistent of deficit and inflation. Like most developing countries, Sudan still continues to relay on foreign trade sector which accounts for 39% of total National Income. The country still depends on the exportation of raw materials (primary products, e.g. agricultural goods exports) as a major source of hard currency and importation of final goods (e.g. manufactured and petroleum products items). This represents and creates great pressures on the term of trade, because the exported primary products items showed a continuous decline in their prices (or values), while the manufactured imported items and oil products items showed a continuous rise in their prices and costs. This position on one hand, lead to a continuous deterioration in the term of trade and on the other hand, represents a real obstacle to the process of internal development of the productive sectors because according to section one of this chapter, the performance of these productive sectors has been subject to or constrained by the fluctuations or changes in foreign oriented industrial policies.Thus for oil-importing developing countries like Sudan, any changes in oil prices in the world market, will directly be reflected in oil prices in the country, and consequently affect the performance of the productive sectors which depends on oil products in their production process.(Farid Omer Madani 1984 pp.6-7, 13-16).

In addition, petroleum products and crude oil as an imported goods have its important effects on the balance of trade, balance of payments, balance budget deficits (i.e. external and internal balance), inflation, and GDP growth rate.

5.3.2 Oil imports and the External Balance:-

5.3.2. (A) Oil imports and Balance of Trade:-

In Sudan, throughout the period (1980-1995), different types of petroleum products were used to satisfy the internal needs particularly the productive sectors (agriculture, industry and transport) requirements. The continuous increase in the internal demand lead to an annual increase in the volume of oil products imports . According to table (5.1.d) and figure (5.1), the annual sectoral oil consumption has changed during the period (1980-1996), the total oil sectoral consumption has increased from 968866 (MT) in 1980 to 1186925 (MT), 1664412 (MT) and 1310094 (MT) in the years 1985, 1990 and 1995 respectively. Moreover, the forecasts of annual oil consumption by type for the period (1996-2010), prepared by the Ministry of Energy and Mining Statistical Unit, assume that total oil consumption by type will increase from 1873 thousand (TOE) in 1998 to 2120, 2916 and 4031 thousand (TOE) in the years 2000, 2005 and 2010 respectively. ((table (5.3) and fig. (5.3)).

As an imported goods crude oil and petroleum products represent a very important items compared with the other imported goods. According to table (5.4) and figures (5.4.a and 5.4.b), the relative share of oil imports to total imports increased from 21.52% in 1980 to 22.68% and 50.49%, in the years 1984 and 1990 respectively, but the ratio declined to 27.97%, 22.77% and 20.57% in the years 1992, 1993 and 1994 respectively. The ratio of oil imports to total imports declined due to governmental policy aims to reduce the annual imports volume and due to the effects of liberalization policies. On the other hand the ratio of total imports volume when oil products excluded from the annual total imports to total imports volume including oil products is declined from 78.48% in 1980 to 77.318% and 49.51% in the years 1984 and 1990 respectively, and the ratio declined to 65.32%, 72.03% and 77.22% in the years 1991, 1992 and 1993 respectively. This means that total imports volume reduced by about 78.48%, 77.318%, 49.51%, 65.32%, 72.03% and 77.22% in the years 1980, 1984, 1990, 1991, 1992 and 1993 respectively due to the omission of oil imports from total imports. (fig.(5-4.c) and (5-4.d))

Therefore, oil products receive a top priority in total imports, list, throughout the period (1980-1993), in most cases the ratio of oil products to total imports is high relative to the other imports items. Consequently, oil imports have an important or serious implications and reflection for the performance of the economy in general, and the performance of the major oil consuming sectors in particular.(i.e. the performance of the major productive sector in the economy).

Oil imports volume increased throughout the period (1980-1994), to the extent that, oil imports bill absorbed the (highest) percentage of total exports revenues, because most hard currency (foreign exchange receipts) generated from exports are directed to cover oil imports bill. According to table (5.5) and fig. (5-5.a), the ratio of oil imports to total exports revenues throughout the period (1980-1993) has increased from 62.563% in 1980 to 68%, 83%, 101.23% and 72.9% in the years 1982, 1990, 1991 and 1992 respectively, but the ratio declined to 47%, 55%, 52% and 46% in the years 1981, 1983, 1993 and 1994 respectively. Therefore, oil imports absorbed most of the exports earnings of the country during the period (1980-1993).

According to table (5.5) and fig. (5.5.b), the ratio of total imports to total exports during (1980-1994), has changed from 291% in 1980 to 251%, 217%, 175%, 214%, 178% and 165%, in the years 1982, 1983, 1987, 1988, 1989 and 1990 respectively. The ratio increased from 165% in 1990 to 292% in 1991, but continuously declined during (1992-1994) From 292% in 1991 to 257%, 226% and 222% in the years 1992, 1993 and 1994 respectively. This could be attributed to the impacts of governmental policies to reduce the total imports volume and to raise the total exports volume, and also attributed to the impacts of liberalization policies after 1992. The decline in the ratio of oil imports volume to total exports volume could be attributed to the above reasons.

These high ratio are also explained by the fact that most exports revenues (hard currency or foreign exchange receipts) expended in or absorbed by imports sector. Moreover, total exports revenues is greatly affected by the deterioration of the term of trade, due to the decline in cotton prices and increase in oil products prices in the world market. This situation created deficit on balance of trade.

Crude oil and petroleum imports have significant impacts or effects on both internal and external balances. This could be verified from their direct impacts on total government expenditures in development items, balance of trade deficit and balance of payment deficit. "Considering the external balance, most foreign aids and foreign assistance (including foreign capital transfers and foreign loans and grants) in the previous time, have been directed to cover the costs of oil imports.(Farid Omer Madani. 1984).

According to Farid Omer (1984), the basic or important impact of oil imports bill on Sudan's economy, stems basically and directly from the fact that it is an annual imported item, that has been purchased on term of international or world market price (i.e. bought in hard currency), and therefore has direct impacts on the balance of trade and indirect impact on the balance of payments (i.e. have a serious effects on the external financial position of Sudan's economy). Throughout the period (1980-1994) oil imports volume annually increased. According to Farid Omer (1984), in 1977 the value of oil imports was about 40 million Sudanese pounds, and has increased to 169 million Sudanese pounds in 1980, i.e. the growth rate (or the percentage of increase) was about 323% during the period (1977-1980), was attributed to the increase of oil consumption and also due to the continuous rise or inflation in oil prices i.e. in the international world market (Farid Omer Madani .1984 pp.17-18).

According to table (5.8) the annual growth rate of oil imports increased from 136% in 1980 to 813% in 1984, but the annual growth rate declined to -22%, 56%, 120%, -1%, -71% and -6% in the years 1985, 1986, 1987, 1988, 1989 and 1992 respectively.

5.3.2.B : Oil Imports and Balance of Payments Deficit :-

The crude oil and petroleum products imports have a negative effect on the balance of payments through their direct impacts on trade balance. Throughout the period (1980-1993), oil imports have aggravated the balance of trade deficit. This claim could be easily verified by analysing table (5.6) and figures (5-6.c) and (5-7.a), according to table (5.6), the omission or subtraction of oil products imports from the total imports will reduce the volume of total imports, reduce the deficit on trade balance and therefore reduce the balance of payments deficit.

The relationship between oil and balance of trade deficit could be verified by analysing table (5.6) and fig. (5-6.a) and (5-6.b), which show the ratio of oil imports to annual total balance of trade deficit. The increase in the volume of oil imports during 1980s, especially at the beginning of 1980s raised the ratio from 33% in 1980 to 47% in 1983. But the government's efforts and policies during the 1990s, specifically during (1990-1993) resulted in the reduction of oil imports and total imports and therefore lead to a reduction in the ratio of oil imports to balance of trade deficit. The ratio was continuously declined from 53% in 1991 to 46%, 41% and 37% in 1992, 1993 and 1994 respectively. According to table (5.6) and figure (5-7.a), the ratio of oil imports to balance of payments deficit throughout the period (1980-1994) has increased from 231% in 1980 to 258%, 564%, 486%, 1196%, 577% and 1343% in the years 1983, 1984, 1986, 1989, 1993 and 1994 respectively. These results show the serious impacts of oil imports in the performance of the economy through their impacts on balance of payments deficit.

Although the relationship between oil imports and balance of payments deficits is indirect, but the figures showed that any increase in oil imports will be reflected in the balance of payments deficit, through the direct effects of oil imports on balance of trade deficits. The balance of payments has increased by one percent due to the increase of oil products imports volume by 231%, 258%, 564%, 486%, 1196%, 577% and 1343% in the years 1980, 1983, 1984, 1986, 1989,1993 and 1994 respectively. During 1990s the impacts of oil imports on the balance of payments deficit became relatively low compared with that of 1980s. According to table (5.11), fig. (5-6.d) and fig. (5-7.b) the annual growth rate of petrol imports was about 136%, 813%, 56%, 120%, -26% and -6%, the annual growth rate in total imports was about 65.1%, -15.3%, 12.8%, 8.8%, 43.9% and -7.8%, the annual growth rate in total exports was about 16.6%, .8%,-1.4%, 79.7%,-18.5% and 4.7%, the annual growth rate in trade deficit was about 106.43%, 3.81%, 22.2%, -28.88%, 139.48% and -14.3%, the annual growth rate in the balance of payments deficit was about -188.98%, -58.29%, -58.68%, -1069%, 33.11% and -42.65% in the years 1980, 1984, 1986, 1987,1991 and 1992 respectively.

5.3.3 Oil Imports and the Internal Balance:-

The impact of oil imports is not only restricted to the external balance, but furthermore affecting the internal balance in the economy. This claim could be explored by comparing foreign governmental expenditures with foreign expenditures in oil sector and energy sector as whole (e.g. fig. (5.8.a) the relationship between foreign development expenditures, petrol sector expenditures and foreign energy sector expenditures). According to table (5.7) and figures (5-8.c), the ratio of government expenditures on oil products to total governmental expenditures, was about 10.19%, 7.64%, 3.93%, 6.52% and 3.78% in the years 1989, 1990, 1991, 1992 and 1993 respectively.

The average ratio of government expenditures on oil products to total government expenditures, throughout the period (1989-1993) was approximately about 6.4%. This indicates that what has been allocated for the importation of oil products represents a real and considerable burden and pressure on public (government) budget.

According to table (5.7) and figure (5-8.b), the ratio of oil imports to total budget deficit during (1989-1993), changed from 8.498% in 1989 to 1.3465%, 0.91% and 2.9768% in the years 1991, 1992 and 1993 respectively. Consequently budget deficit has increased by one percent because oil imports has increased by 8.498%, 1.3465%, 0.91% and 2.9768% in the years 1989, 1991, 1992 and 1993 respectively. Although the relationship is indirect but the figures showed that any increase in oil imports expenditures will be reflected on balance budget deficit.

Furthermore, oil products absorbed about 10.19%, 7.64%, 3.93%, 6.52% and 3.78% of total government development expenditures in 1989, 1990, 1991, 1992 and 1993 respectively, and absorbed about 23.823%, 19.93%, 6.72%, 14.15% and 12.96% of total foreign development expenditures in the years 1989, 1990, 1991, 1992 and 1993 respectively fig.(5.8.e). On the other side, total energy sector absorbed about 7.067%, 7.22%, 16.57%, 12.429% and 19.948% of total development expenditures in the years 1989, 1990, 1991, 1992 and 1993 respectively fig.(5.8.d), moreover, the ratio of foreign expenditures in energy sectors to total foreign development expenditures was about 9.45%, 14.28%, 21.18%, 7.82% and 8.09% in the years 1989, 1990, 1991, 1992 and 1993 respectively fig.(5.8.f).

5.4. Oil Imports, Inflation and Development :-

5.4.1 Oil, Inflation and Development in the Developing Countries:-

Inflation is defined as a general upward trends in prices levels and occurs when the available or desire purchasing power of the population in certain area exceeds or outweigh the available supply of goods and services. On the other hand, it is defined as a continuous decline in the value of national currency or its purchasing power or its exchange rate relative to the other foreign currencies (e.g. dollar). In this way inflation usually result due to increase in the demand for goods and services without an equivalent increase in the supply of these goods and services. The excess demand result either from a continuous increase in the purchasing power or a continuous decline in the supply of goods and services. The inflationary rate depends on the relationship between the desire to spend money and the rate at which goods and services are supplied, or it depends on the rate of money creation by higher or greater percentage than the productive rate.(Mohamed Nory Hamid.1984 pp.1-3)

Inflation has many causes, it might be attributed to a general increase or rise in wages and costs, structural difficulties and increase in general imports (costs and prices) (i.e. imported inflation).(Mohamed Nory Hamid. 1984)

Recently, the study of inflation and their impacts become important especially in the developing countries, because it is considered one of the basic or serious obstacles that constraint the economies of these countries. Economists considered it as the first enemy for all nations, and they argued that the failure of curing inflation will lead to or result in misallocation of resources and also have a direct impacts on political and economic distabilization. (Mohamed Nory Hamid. 1984. pp. 1-3)

The significant correlation between oil and development and oil and inflation has been evaluated after the expansion in oil discoveries and oil exploitation. (Mohamed Nory Hamid 1984). Edelman argued that "the sudden termination of the period of cheap and abundant oil and natural gas in the late of 1973 has caused severe difficulties in most of the less developing countries. During this period, studies and experiences of oil producing exporting countries 'OPEC' and oil importing countries verified that there exist a strong relationship between oil and inflation".(Manas Chatterji 1981.chap.(10) p.167).

"The experiences of oil producing and exporting 'OPEC' Arab countries during 1970s, revealed that, the increase of oil prices and the sudden increase in oil discoveries and exploitation lead to increase in production levels and total revenues generated from oil sector. These has been accompanied with increase in money supply, which has doubled many times during the same period, in addition to the increase in total public and private expenditures on infrastructure and services sectors, which have also doubled many times during the same period, there was also increase in the prices of locally produced and imported goods and services. In addition to increase of the value of national currency relative to or compared to the other foreign currency, (e.g. dollar). These monetary and fiscal expansions have been accompanied with general upward trend in consumption and government spending, which has both raised aggregate demand level without an equivalent or adequate increase in aggregate supply level.The excess demand over supply caused a higher inflationary rate in both oil producing exporting countries and oil importing developing countries. During 1970s with the increase of oil prices, these countries experienced a higher inflationary rate, for example, in Iran, the increase of oil prices and revenues in 1971/72, have been accompanied with a higher inflationary rate, because oil revenues increased by about 74% and inflation increased by 9.7% in the same year. Another example, in Nigeria, according to the World Bank and IMF statistics in 1980s, the increase of oil prices and revenues raised inflation by 20%, the increase of oil prices during (1975-1980) in Nigeria raised the value of national currency relative to dollar and other foreign currency. These have been accompanied with increase in government spending in public sector investment, these in turn raised aggregate demand level and therefore resulted in more inflation. The increase in total consumption in Congo and general total consumption and investment in Gabon, during the same period has raised aggregate demand caused excess demand over supply and therefore raised inflationary level or ratio". (Mohamed Nory Hamid March 1984 pp.3,6-9,15-16).

5.4.2 Oil and Inflation in the Sudan :-

Inflation today represents a serious economic problem for both developed and developing countries, because it represents a chronic problem or dilemma that faces and negatively affects the economies of most, if not all the developing countries.(Mohamed Nory Hamid. 1984 P.2).

For most economists the changes in the consumer price index (CPI) used as a measure of inflation. In Sudan during the period (1980-1990), the inflationary rate measured by the growth rate (changes) in CPI (i.e. ΔCPI/CPI), has increased from 26.2% in 1982 to 47.6%, 70% ,120.5% and 119.5% in the years 1988, 1989,1991 and 1992 respectively.

During the 1970s, the oil crisis has generated a significant inflationary pressures in both the developed industrialized and the developing countries and these negatively affected output levels. The 1970s experience showed or emphasized that, in the developing countries particularly oil-importing developing countries, inflation and imports are closely interrelated. In most of these countries (including Sudan), the major economic productive sectors in the economy depend mostly on imported commercial energy source like oil products. So any increase in the costs or prices of imported energy will directly be reflected in the costs or prices of locally produced commodities that consume the imported energy (oil products). Therefore, the importation of oil directly or indirectly contributes in raising the general inflationary rate, through their direct impacts on general prices level of domestic commodities produced by the economic productive sectors which depend on oil products. (Mohamed Nory Hamid 1984 pp. 3-6)

Although the quantification of the impact of an increase in oil prices and other commodities on inflation is not an easy process to count, but according to table (5.9) and figure (5-10), the relationship between oil imports and the general inflationary rate measured by the changes or growth in CPI, is considerable or significant. The annual growth rate of CPI increased from 26.1% in 1980 to 26.2% and 31.1% in 1982 and 1983 respectively. The growth rate increased to 32.5%, 46.2%, 47.6% and 70% in the years 1984, 1985, 1988 and 1989 respectively. On the other hand, the annual growth rate in oil imports increased from 136% in 1980 to 813% in 1984. This led to increase in inflationary rate as measured by the annual rate of growth, (or changes) in CPI, the relationship between them defined by the ratio of oil imports growth rate to CPI growth rate has doubled by five times during the period (1980-1984), due to the increase in oil imports growth rate, the ratio increased from 5% in 1980 to 25% in 1984. This implies that any 5% and 25% increase in oil imports raised inflation by one percentage in 1980 and 1984 respectively i.e. the growth rate in oil imports from 136% in 1980 to 813% in 1984 contributed in the increase of inflation from 26.1 in 1980 to 32.5% in 1984. In (1991-1992) oil imports growth rate changed from -26% in 1991 to -6% in 1992, while inflation (growth rate in CPI) declined from 120.5% in 1991 to 119.5% in 1992 (by one percentage), and the ratio of oil imports growth rate to inflation (CPI) growth rate changed from -0.2% in 1991, to -0.05% in 1992.

Thus the relationship between oil imports growth rate and inflationary growth rate (changes in CPI) is evident, the relationship is strong during 1980s and relatively weak during 1990s. However, in general oil imports growth rate and general inflationary growth rate are significantly correlated in the Sudan.

5.5. Total Energy, Oil Imports and GDP Growth Rate :-

Since energy is a key input in the key productive sectors in any economy, it is an indispensable, necessary, inelastic and irreplaceable element or input in the production process in any economy, (e.g., it is necessary for lighting, heating, power and machinery work (Michael Tanzer, 1969 p.4).

Despite the fact that, energy growth rate assumed to be closely inter-related to the annual growth rate in the gross national product or gross domestic product in any economy, however, in the Sudan the contribution of energy sector in GDP is very low and marginal and never exceeded 2.5% during the period (1980-1990) namely the contribution of electricity and water sector in GDP was ranged between 1% and 2.3% during the period (1980-1990).

The relationship and linkage between energy sector and the other productive sectors in the economy stems from the fact that energy input is an intermediate input in the major productive sectors. Theoretically, this interrelationship and linkage is defined through input-output (model) table or analysis, which identifies the relationship between energy sector and the other productive sectors in the economy. The model explains how much energy used by these sectors i.e. by how much energy input contributes in the production of these sectors and how these sectors contribute in energy sector production. However, due to unavailability of adequate information and data necessary for the construction and formulation of the model, so for the present study, it was no longer possible to verify the relationship between energy sector and the other productive sectors in the national economy through the construction or formulation of input-output model or technique. So the present study resort to use the analysis which identifies the relationship between energy sector and the gross domestic product as a mean to verify the importance of energy sector in general and oil sector in particular to the growth rate in gross domestic product.

Theoretically, it is assumed that, the growth rate in total energy consumption is associated with growth rate in GDP. According to table (5.10) and figure (5-11.b) total energy growth rate increased from 0.07% in 1981 to 3.95% and 4.02% in 1985 and 1988 respectively, while GDP growth rate increased from 4.6% in 1981 to 10.2% and 5.6% in 1985 and 1988 respectively. In 1987, total energy growth rate increased to 5.22%, but GDP growth rate declined to 1.5%.

According to table (5.10), the annual growth rate of biomass changed from 2.70% in 1981 and 1982 to 2.69%, 2.65%, 2.60%, 2.61%, 6.16% and 5.92% in the years 1983, 1984, 1985, 1986, 1987 and 1988 respectively. On the other hand, electricity sector annual growth rate declined from 7.09% in 1981 to -.33% in 1982 but increased to 26.98%, 9.76%, 11.79% in the years 1983, 1984 and 1985 respectively but again declined to 4.36, -11.19% and -12.91% in the years 1986, 1987 and 1988 respectively. The annual growth rate in oil consumption changed from -9% in 1981 to 6.3%, -3.72%, 4.08%, 7.62%, 5.78%, 5.22% and -1.49% in the years 1982, 1983, 1984, 1985, 1986, 1987 and 1988 respectively.(Table(5.10) and fig.(5-11.b) and (5-11.c)).

According to table (5.12) and fig. (5-11.a), the ratio of electricity consumption to total energy consumption is very low and changed from .0109 in 1980 to .0117, .0113, .0152, .0163, .0178,.0179,.0153, .0130 and .0156 in the years 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988 and 1989 respectively, the ratio of biomass to total energy consumption is very high and changed from .7391 in 1980 to .7591, .7527, .7609, .7575, .7470, .7409, .7483, .7634 and .7671 in the years 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988 and 1989 respectively, on the other side, the ratio of petrol consumption to total energy consumption changed from .2499 in 1980 to .2299, .2360, .2238, .2262, .2352, .2411, .2364, .2236 and .2172 in the years 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988 and 1989 respectively. Although, electricity have the lowest share in total consumption compared with biomass and petrol, however, according to fig.(5-11.d) during the period (1981-1989), the average growth rate in electricity sector is greater than the average growth rate in biomass and petrol sectors, i.e. the average growth rate in electricity biomass and petrol sectors was about 63.5%, 26.1% and 10.4% respectively, according to table (5.10) and fig.(5-11.b) and (5-11.c) the annual growth rate in electricity sector during the period(1981-1988) in some cases is greater than the annual growth rate in biomass and petrol sectors.

According to table (5.8) and fig.(5.9), during 1980s, in some cases the annual growth rate in oil imports is greater or higher than the annual growth rate in GDP, for example, the annual growth rate in oil imports was about 136%, 95%, 813%, 56% and 120% in the years 1980, 1982, 1984, 1986 and 1987 respectively. While the annual growth rate in GDP was about 2.81%, -2.7%, -11.5%, 4.9% and -1.5% in the years 1980, 1982, 1984, 1986 and 1987 respectively. During 1990s the annual growth rate in oil imports changed from -26% in 1991 to -6% in 1992 and the annual growth rate in GDP increased from 11.3% in 1991 to 12.3% in 1992. The highest growth rate in oil imports was about 813% and 120% in the years 1984 and 1987 respectively, compared with -11.5% and -1.5% growth rate in GDP in 1984 and 1987 respectively. The highest growth rate in GDP was about 11.3% and 12.3% in the years 1991 and 1992 respectively, compared with -26% and -6% growth rate in oil imports in the same years. The interval of oil imports growth rate was -99 (minimum rate) and 813 maximum rate. On the other hand, GDP growth rate interval was -11.5 (minimum rate) and 12.3% (maximum rate).During 1980s oil imports growth rate exceeded the annual growth rate in GDP , however, during 1990s due to continuous decline in total imports and oil import the annual growth rate in GDP exceeded the annual growth rate in oil imports.

According to table (5.10), the growth rate in energy sector was about 3.52%, 1.63%, 3.09% and 5.22% in the years 1982, 1983, 1984 and 1987 respectively. While the annual growth rate in GDP was about -2.7% , -2.9%, -11.5% and 1.5% in the years 1982, 1983, 1984 and 1987 respectively. However, in the years 1981, 1985, 1986 and 1988 GDP growth rate exceeded energy sector growth rate, because the growth rate in energy sector was about 0.07%, 3.95%, 3.4% and 4.02% compared with 4.6%, 10.2%, 4.9% and 5.6% growth rate in GDP in the years 1981, 1985, 1986 and 1988 respectively.

These argument verified the inter relationship between energy sector, oil sector and GDP, in some cases energy sector and oil sector annual growth rates exceeded the annual growth rate in GDP.

5.6. Conclusion:

It is obvious that energy sector is important to the productive sectors in any economy because energy sector growth rate assumed to be necessary for GDP growth rate. In Sudan, although energy sector absorbed about 7.1% and 19.95% of total governmental expenditures and absorbed about 9.45% and 8.09% of total foreign expenditures in the years 1989 and 1993 respectively, however energy sector contribution in GDP is very low and marginal and never exceeded 2.5% during the period (1980-1990) e.g. the contribution of electricity and water sectors in GDP during the period (1980-1990) is ranged between 1% and 2.3%.

In Sudan, oil is the major commercial energy type used by the economic productive sectors, because oil products directly affect the production levels of these productive sectors. Moreover, oil imports have serious impacts on both external and internal balances, through its impacts on balance of trade deficit, balance of payments deficit and balance of budget deficit.

In fact, the direct impact of oil in Sudan economy obvious in total imports and balance of trade deficit. Throughout the period (1980-1993) oil have the highest percentage and represents the major item in total imports list, it accounted for 21.52% and 34.67% of total imports in 1980 and 1991 respectively. Moreover, oil sector absorbed the highest ratio of total exports revenues, it absorbed about 62.563% and 101.23% of total exports revenues in 1980 and 1991 respectively. Moreover, oil contributed by about 33% and 53% of balance of trade deficit in 1980 and 1991 respectively. Consequently, the omission of oil imports item from total imports list in 1980 and 1991 has reduced the total imports by about 78.48% and 65.32%, reduced the balance of trade deficit by about 67% and 47% in 1980 and 1991 respectively.

Moreover, oil imports also affect the internal balance through affecting total and foreign expenditures and balance budget deficit. Oil imports absorbed about 10.19% and 3.78% of total government development expenditures, and absorbed about 23.823% and 12.96% of total foreign expenditures in 1989 and 1993 respectively. Consequently ,oil imports sector accounted for about 8.498% and 2.9768% of total balance budget deficit in 1989 and 1993 respectively.

On the other hand, the relationship between the annual growth rate in oil imports and inflation is significant, and therefore, support the argument that the increase in inflation in Sudan among other thing, is attributed to the increase in total imports in general and oil imports in particular. During (1980-1993) the annual growth rate in oil imports significantly affected inflationary rate. The annual growth rate of inflation increased from 26.1% in 1980 to 32.5% in 1984 and the annual growth rate in petrol increased from 136% in 1980 to 813% in 1984. Consequently the ratio of oil imports growth rate to inflation growth rate was doubled by five times from 5% in 1980 to 25% in 1984, this implies that any 5% and 25% increase in oil import raised inflation rate by one percent in 1980 and 1984 percent. Therefore, oil imports and total imports significantly contributed in general increase in inflation.

CHAPTER SIX
ECONOMICS POLICIES AND ENERGY PROBLEMS

Chapter Six

Economic Policies and Energy Problems

6.1.A Introduction:

Recently considerable attention and efforts directed and devoted toward energy conservation strategies, because "By the early of 1970s, most developed countries experienced decades of low energy prices and plentiful fuel supplies, with consequent of high and growing percapita use of energy. This high usage was of little concern to most governments until the first oil shocks, when rapidly rising energy prices and interruptions in supplies forced re-examination of existing policies. In most developed countries conservation and end use efficiency improvement became an important components of energy policy. In the developing world the continued rapid growth in energy demand and its financial and environmental consequences have stimulated renewed interest in the potential to improve efficiency in both supply and end use" (The World Bank -1993 pp.18-19).

Since, increasing energy consumption and economic growth are strongly and positively correlated, recently, in the context of an integrated comprehensive energy policies management, in both developed and developing countries, most efforts and strategies are essentially directed and devoted toward energy conservation, rationalization and increasing energy efficiency to the extent that energy conservation strategies and energy supply-demand theorem or policies are now been viewed in a broader context of national development strategy. In the Sudan considerable efforts are directed or devoted to include or implement a comprehensive energy development strategy in the broader context of national-sustainable development strategy.

The present chapter focuses on economic policies which usually implemented to deal with energy (crisis) problems. Section one defines the general energy problems from an economic point of view. Section two provides a macro solution of these problems. Section three provides a microeconomic (or sectoral) solution for the three types of energy used in the Sudan, the last section concludes and summarizes the main points.

6.1.B An Economic View of the Nature of Energy in the Sudan and the Developing Countries:

Recently in the developing countries, there are increasing attention or awareness about reforming energy policies (including supply side, demand side, energy prices and efficiency issues) and managing energy crisis. The world Bank (1993), study in the developing countries, demonstrated the fact that those countries faced a rapid growth in the demand for energy with major constraints in financing available energy sources and increased pressures to sustain environment (The World Bank 1993, chap.(1) and (2) pp.10-15).

The World Bank study (1993), specified four major critical factors that cause differences in energy sector performance in the developed and developing countries, these factors include, differences in energy pricing policies, policies (or mechanism) for controlling or regulating energy supply enterprises, the extent to which energy using industries are protected from competition and the legal institutional and informational barriers to the efficient functioning of markets. (The World Bank. 1993, chap.(1) and (2) pp. 10-15).

In most developing countries including Sudan, energy crisis is attributed basically to four fundamental and major problems these are, "low supply because energy is scarce, high and increasing demand, low efficiency and high percentage of losses, inefficient pricing system due to low price and subsidies that creates price distortion". (The World Bank. 1993, chap.(1) and (2)). These four major problems directly or indirectly related to energy crisis in the Sudan and in most other developing countries. Consequently, all efforts deal with or directed to manage the energy sector crisis must consider all these factors.

6.1.1 Inefficient Pricing System (Low Energy Price):

It is a major and fundamental issue confronting the energy sector in the developing countries. The World Bank (1993), demonstrated that "prices in most developed countries are set with the object of covering at least the full financial costs of supply, but in many developing countries including Sudan, energy prices (other than some petroleum products), do not cover the economic costs or full financial costs of supply. This means that energy consumers many of whom produce other goods, do not face prices that encourage them to use energy efficiently, selects the most economic fuel, or use the technology that would best meet their needs. In the transport sector fuel are used inefficiently when fuel prices are below boarder prices, and when there are distortion producing prices differentials among alternative fuel (gasoline, diesel and kerosene). The World Bank (1993) experience and study in sixty developing countries, demonstrated that on average tariffs for nearly 80% of the utilities in those countries did not cover the long run marginal cost of supply, in addition to encouraging wastage in energy end use efficiency and making many energy efficiency conservation and technology initiatives financially unattractive". (The World Bank, 1993, chap.(4) pp.36-37).

6.1.2 Shortage in Supply:

In the developing countries, energy crisis could be viewed in a macroeconomiccontext through the analysis and investigation of supply-demand sides. According to Sudan's National Energy plan (1985-2000).

the Fundamental problem with regard to energy sector is that supply lagged behind demand, this problem attributed to the increase of oil prices after the period (1970s-1980s) and a reduction of the ability to import oil or petrol, due to inadequate capital investment, fuel allocation, electricity load shedding and emergency investments to bridge the gap, these resulted in completely unreliable energy supplies for the consumers, which caused losses to the economy and the gap continues to grow as the suggested solutions fail to solve the fundamental problems.

The World Bank study (1993), demonstrated that institutional and supply side inappropriate investment decisions and government intervention in the day to day operation of energy supply enterprises resulted in a large economic costs and financial losses. (The World Bank, 1993, chap.(1) p.14).

The basic three sources of energy in the Sudan face these problems . Traditional fuel wood sector suffers due to diminishing forests stock and desertification problem. Electricity sector suffers from unreliable supply and discontinuous generation (peak period interruption). Petroleum sector suffers from low inadequate supply due to shortage of foreign exchange receipts and hard currency.

6.1.3. Excess-Demand:-

It has been evident that energy crisis in the developing countries is basically attributed to the problem of excess demand. In Sudan the growing and increasing energy requirements and needs of the productive sectors in the economy resulted in excess demand, which creates problem of shortage in most energy sources, particularly commercial energy. This resulted in the appearance and emergency of black market particularly in petroleum products sector. The problem of excess demand and low supply lead to inefficiency in energy sector market. Recently, the government resorted to introduce and implement commercial prices that cover the costs of supply to reduce the excess demand and to create balances in energy market and to eliminate or at least reduce the gap between the supply of energy and the demand for energy.

6.1.4 Inefficiency and Losses Problems in the Energy Sector:-

Losses and inefficiencies appear clearly in energy balance for all countries, but varies across countries due to many factors, the major ones are related to the country's degree of development, the prevailing technical levels or standards, and the increasing public (general) awareness about losses and their socio-economic implications (Gamal Osman Abubaker 1991 - Sudan Energy News 1991 p. 15-18).

Inefficiency and losses in energy represent a serious problems that constraint the perfect performance of energy sector. According to the World Bank (1993), "Energy efficiency is not a well defined concept, it has two aspects; magnitude efficiency or "x" efficiency and price efficiency more recent literature suggested that "x" inefficiencies exist at both production and consumption sides of energy, one frequently used empirical measures of energy efficiency in energy use per unit of GDP. However, in the context of development, it is the economic rate of return to capital that is relevant, not energy use per unit of output of GDP. According to World Bank (1993), pursuing energy efficiency is desirable or required up to the point where the changes in the economic rate of return become zero or negative, or alternatively where the rate of return is greater than or equal to the cost of capital" (World Bank. 1993, p.15). In this way increasing subsidies and raising technical managerial inefficiencies resulted in a reduction of the rate of return to investment and against enhancing energy efficiency and conservation objectives. There is an argument that, historically one of the driving forces of increasing energy efficiency is the increase in energy prices relative to or compared with the other economic factors. (The World Bank. 1993).

In the developing countries, the problem of losses is particularly acute. According to the World Bank study (1993), a sample of '51' developing countries, revealed that older power plants in many developing countries consume from 18% to 44% more fuel per Kilo Watt hours (KWH) of electricity produced than do plants in OECD countries (The World Bank. 1993). This high percentage of losses is attributed to many factors; (1) many governments failed to pass on all of increase in international energy prices to domestic producers and consumers. (2) In many countries a large part of total consumption is in non household sectors which are dominated by inefficient state (public) enterprises and protected industries, these protected industries has relatively high consumption per unit of output (3). Subsidized publicly owned monopoly enterprises supply energy on cost plus basis did not provide a conclusive environment for effective built in continues for the high levels of efficiency. (4) Because of non competitive market structure and subsidized energy prices, it has not been profitable for market intermediaries to develop to arbitrate information on energy efficiency or on financial and technological options. In this way, lack of information intermediation resulted in a relatively higher costs of information financing and management expertise. (The World Bank. 1993, chap. (2), p. 19).

In Sudan energy efficiency problems appeared in the forms of loss in transmission, conversion, distribution and transportation. In some years total supply is relatively high but losses occurred in the forms of transmission, distribution, conversion lead to reduction in the total supply. According to Energy Hand Book (1987, 1990 and 1991), the estimated losses on average was about 4 million ton oil equivalent, which represents about 40% of total energy supply in the years (1987, 1990 and 1991), this implies that only 60% of total energy supply reaches end users.

According to Gamal Osman (1991), in Sudan losses might appear in the form of direct losses that occur or associated with energy generation (e.g. electricity), transmission, conversion and distribution (e.g. petrol), or in the form of losses that occur due to institutional, managerial, administrative or organizational factors, delays in enforcement or implementation of projects plans, demand mismanagement and absence of qualified laws for rationalization. These forms of losses occur due to a many reasons such as weak infrastructural bases which include low technical and qualified transportation and communication system, absence or inadequate qualified technical workers to manage losses problem, inefficiency in working capacity due to technical problems related to machines and equipment operations, inefficiency attributed to low experiences and ignorance to deal with technology. In addition to financial problems (economic factors), losses also attributed to the shortage of foreign exchange receipts and hard currency which constrained the imports volume of both petroleum products and spare parts used by machines and equipment,the weak role of the private sector investment in energy sector. In addition to difficulties and mis-allocation in sectoral distribution. Moreover, administrative, managerial and organizational problems contributed in losses problems. In addition to the lack of expertise and experience or knowledge to deal with these problems. Moreover, losses occur due to social reasons due to the fact that most consumers have low concern and awareness about losses problems and their socio-economic implications, these attributed to ineffective and weak role of awareness efforts on one side, and also due to the nature or pattern of demand for energy in the Sudan which lead to the failure of efforts to reduce the total demand for energy through regulatory laws and economic tools and policies particularly pricing policies because energy demand is price inelastic and consumers are less responsive to changes in prices, and also due to the failure of interfuel substitutions policies that constrained by difficulties in modifying the behaviours or preferences of consumers to shift to the other substitutes sources which are characterized by the maximum benefit, high efficiency, low costs and minimum losses (i.e. have low technical, economic and environmental costs). (Gamal Osman Abubaker 1991- Sudan Energy News 1991, pp.15-18).

According to the World Bank (1993), both developed and developing countries experienced market imperfection problems, that create significant barriers to efficient energy production and end users. These include, (1) lack of a government energy record on consistency, predictability and credibility policies to encourage energy efficiency. (2) Information gaps on energy losses reduction techniques, technology and process options finance and joint venture opportunities, due to lack of market intermediation and high transaction costs. In the household sector in particular, energy users do not usually have easy and low cost access to necessary technical information and capital, and first time applicant buyers do not generally have sophistication to understand the potential differences in the costs of on going energy consumption. (3) Household end use energy consumers usually do not face the real costs of energy use, because households are often not adequately metered and because investment decisions are often split among tenants, owners and contractors. In addition to these barriers, other factors tend to be associated with lower level of energy efficiency, these include the general availability of energy inefficient applicances, equipment and structures, partly due to absence of minimum energy efficiency codes and standards for commercial building and for small consumers items such as applicances and motor vehicles and a weak institutional capacity to enforce such codes and standards. (The World Bank 1993, chap.(6) p. 49).

It has been evident that increasing efficiency and promotion of energy sector are positively interrelated to the growth of GDP. However, the growth in energy demand which has not been accompanied with an increase in supply creates imbalances in energy market or supply-demand gap. These problems and other environmental related problems raised the importance of energy conservation issues.

Recently, energy conservation is extremely important and represents a top goal, objective or priority to policy makers in both developed and developing countries, particularly after the 1970s oil shocks because most energy products became increasingly expensive, therefore, extensive efforts addressed to increases and push the attention, awareness and importance to secure the available energy resources, by choosing among alternatives to create optimal allocation of available resources at least possible costs (economic efficiency), promoting allocative efficiency through ranking priorities and directing the available supply in order to satisfy the basic needs and reducing or eliminating unnecessary (or extravagant) consumption.

In Sudan, improving energy sector efficiency and conservation requires the formulation and implementation of an integrated energy strategy within a comprehensive development strategy. An integrated energy plan must find solutions to the fundamental problems facing the sector, these include: (1) Energy demand management. (2) Energy supply management and structural reform. (3) Interfuel substitution policy. (4) Adjustment and reform of pricing system, (5) Promoting and enhancing efficiency and reducing the losses to their minimum possible standards. (6) Enhancing and implementing the regulatory and rationalization policies.

6.2. The Mechanism of Solving Energy Problems in the Sudan (Macro Policies) :-

6.2.1 Adjustment of Energy Pricing System:-

The mechanism of solving energy crisis in the Sudan necessitates the correction of energy pricing system as a top priority and a focal point, because pricing policies considered as a very effective mean or tool in controlling the demand side and regulating market mechanism, because pricing policies have a direct effect in final consumption, useful to cut extravagant consumption, and help to serve rationalization and regulation objectives through directing supply toward urgent economic needs (ranking objectives) and help in allocating exploiting and using the existing internal or domestic sources in an optimal way. Consequently, short-medium and long term plans must put or consider pricing policies as a top objective to reflect the real costs of supply. According to the World Bank (1993), "reforming energy pricing system means set energy prices to reflect the real costs of supply and to have prices that cover long term marginal costs, this implies that energy consumers must face prices that encourage them to use energy efficiently". (The World Bank. 1993, p.43).

The World Bank (1993), recommended that "as a part of the overall energy pricing, power suppliers and gas suppliers should pursue active load management programmes that are responsive to time of use, type of uses and quality of supply. While the impact of price changes may not be longer in the short run, but the experience of 1970s and early 1980s oil shocks, showed that the longer term efficiency impact can be quite dramatic in competitive markets". (The World Bank. 1993, p.43).

In Sudan, inefficient pricing system (distortion problem) caused by cross subsidization, because prices of fuel, do not reflect the real costs of supply, and this lead to market imperfection. In addition, to the problems of excess demand, shortage of supply and supply-demand gap, cause imbalances in energy market. Thus pricing system reform is inevitable as a tool of adjusting and correcting market condition. Energy pricing policies in the Sudan, should be effective, if they are managed to (1) restrict and cut the extravagant consumption through increasing the awareness and raising the consciousness among the final consumers about the gains and benefits from conservation and ratioanalization policies. (2) Correct prices as far as possible and issuing taxes for high income group (those who are able to pay for) as a mean of restricting the extravagant consumption. (3) Increase technical and allocative efficiency at the consumption production and distribution levels. (The National Energy Plan, (1985-2000).

According to Gamal Osman (1990), since energy products are a vital input in the productive sectors of the economy, therefore, the reform of energy pricing system have a significant impacts on most consuming sectors.Therefore, feasibility studies that measure the impacts of pricing system reform, subsidization and taxes on energy prices and the consuming sectors that have a significant share on GDP, must be prepared and annually formulated.These studies have to analyse the impacts of subsidies and taxes on energy prices and their impacts on GDP and final consumption.The impacts of energy pricing unification, and the impacts of pricing policies on interfuel substitution, and the extent of their effectiveness in modifying the consumers preferences for certain energy sources, i.e. changing prices of substitutes to encourage consumers to shift toward the products or sources that have low costs and low prices and have low environmental and economic costs. (Gamal Osman Abubaker. 1990 -Sudan Energy News 1990).

In this context, pricing policies and interfuel substitution policies are more effective in modifying rural and urban household preferences of using biomass charcoal and fuelwood (which have a serious environmental costs) through substituting these fuel by reducing the prices of kerosene and L.P.G. to encourage consumers to shift toward them and therefore reducing the environmental and ecological costs which are associated with the consumption or usage of biomass (fuelwood and charcoal) as a basic energy source. In this way substitution will be useful in supporting and serving the environmental conservation objectives and sustainable development objectives. (The National Energy Plan .(1985-2000)).

6.2.2. Supply Side and Structural Reforms:-

In the broader economic context, supply side and structural reforms are considered one of the most important tools in dealing with energy problem in both developed and developing countries. It is crucial to determine what approaches and polices used to enhance and promote or raise the domestic energy supplies, concentrating upon manageable number of alternatives that achieved through pursuing energy supplies options. (The National Energy Plan , (1985-2000)).

Supply side polices must focus on increasing efforts to make energy available at right and critical times for all consuming sectors with especial emphasis and consideration being directed to satisfy the top priorities or needs on one hand and also increasing allocative efficiency and optimal use with least possible costs. Moreover, supply side reform must focus on encouraging private sector investment and policies to promote the internal domestic supply sources, that produce adequate supply with least possible costs that are technically and economically efficient. (The National Energy Plan, (1985-2000)).

The World Bank (1993), recommended that "restructuring supply side will aim at making energy supply enterprises more autonomous and decision-making more transparent, and the improvement of managerial efficiency that would arise from institutional reforms and greater private sector participation, which are depend on achieving good financial rate of return that would leave the enterprises financially able to undertake required maintenance and reduce physical losses". (The World Bank, 1993, chap.(1) p.14).. Thus supply side policies will be more effective through the establishment of strong institutions, availability of highly qualified and well trained workers (man power). Formulation and issuance of legal regulatory policies and elimination of government intervention as far as possible, i.e. making autonomous entities capable to promote supply side", (The World Bank. 1993). Increasing supply and concentration on sectors which are characterized by highest efficiency and lowest fuel uses like river and railway transport used as a substitutes for road transport. Moreover, making supply side institutions responsive through institutional and regulatory reforms. (The National Energy Plan, (1985-2000)).

In Sudan, the National Energy Plan (1985-2000), recommended for managing the supply side through institutional organizational reforms, enforcement of comprehensive plans and strategies, enhancement of workers qualifications and manpower development, increasing efficiency, in staffing, managerial, administrative and accountability, these changes will result in improving the performance of the energy sector as relevant decision and plans will be implemented more effectively.

6.2.3 Demand Side Management:-

Recently, demand side management strategy considered as a focal point in energy conservation policy, because the nature of energy problem often stems from excess demand for energy. Previously demand side did not receive adequate attention because all concentration was on or upon supply side to meet the growing or increasing demand. But after the 1970s and the early of 1980s oil shocks, due to increasing prices and costs of energy generation it is inevitable to focus on the demand side. It has been claimed that, "Future public policy with respect to energy supply cannot be made in isolation, precise guide lines will depend at least partially on decisions concerning the demand side of the equation and perceptions of possible constraints on any actions". (The World Bank, 1993).

In Sudan it is inevitable to introduce and implement strategies to exploit the available internal supply sources which will help in creating adequate supply by more effective means, these could be achieved through more effective means and a comprehensive strategies which are directly related to demand side, since it is now a basic tool to control energy sector demand growth. The demand side management strategies requires the following:- (1) Ranking priorities and directing or allocating the available supply to satisfy the top priorities, enhancing economic efficiency, eliminating and discouraging the low priorities that have low economic efficiency. These could be achieved through using pricing systems and taxation tools. (2) Controlling consumption through introducing and enforcing rationalization policies or laws by increasing awareness among final consumers and directing them toward the optimal choices, and eliminating extravagant consumption as far as possible. (4) Encouraging new investment (both public and private sectors), to increase the supply of various sectors. (5) Introducing structural changes by using or choosing the efficient modes of consumption (i.e. economically and technically efficient modes), (e.g. using public transport, buses instead of private means, cars), using railway and river transport instead of road transport). (The National Energy plan, (1985-2000)).

According to Sudan's National Energy Plan (1985-2000), demand side management represents the basic tool to achieve the short run objectives. Demand management could be achieved through (1)The usage of appropriate economic tools such as pricing and taxes, to promote efficiency among all consumers. (2) Implementation of aggressive conservation strategies to restrict extravagant consumption. (3) Minimization of the use of controls or allocation as far as possible. Thus demand side management strategies aim to modify the patterns of energy demand or usage, for example in electricity sector demand management strategies aim to reduce peak load or slow it's growth and therefore defer the needs for additional capacity to meet peak load. (National Energy Plan, (1985-2000)).

6.2.4 Rationalization of Energy Use:

Rationalization of energy use is one of the basic tools pursued to manage energy crisis. Many developing countries managed to achieve satisfactory results through pursuing aggressive rationalization and regulatory strategies and through enhancing the end use efficiency and technical efficiency. (The National Energy Plan (1985-20000)).

According to Gamal Osman, (1991) increasing public or consumers awareness about regulatory laws or rationalization is considered to be a focal point required for the success of any energy strategies. So emphasis must be on defining the concept of rationalization and regulation among the end users by specifying the benefits or gains obtained from these strategies to reduce total consumption to its minimum acceptable level and to generate the maximum optimal and high efficiency and benefit. Such policies must be formulated at the national level and in a broader context, that include many aspects or dimensions, like awareness about reducing losses in energy production, promotion of ecological and environmental balances by using the most cleanest substitutes without polluting the environment or diminishing the stock of forests or increasing desertification, awareness about gains or benefits obtained from optimal (efficient) uses of various energy sources, awareness about the role of consumers (individual households) to fill the gap between supply and demand in energy balance, awareness about socio-economic and political implications of energy crisis, awareness about energy pricing policies as effective mean or tool of rationalization. All these could be achieved through the formulation of a comprehensive awareness efforts that use various means (like advertisement, such as radio, television, newspapers and magazines) and through regulating, organizing or conducting seminars, lectures and workshops to define the importance and benefits or gains generate from the implementation of rationalization policies and regulatory laws. (Gamal Osman Abubaker. 1991 -Sudan Energy News. 1991, pp.22-28).

Rationalization of consumption in basic productive sectors like agriculture, industry, transport and household sectors help to save, preserve or conserve about 20% of total energy consumed in the country (Sudan Energy News, p. 18, Sept. 1991).

6.2.5. The Mechanism of Reducing and Controlling Losses as a tool of Energy Conservation:-

In Sudan, technically it is difficult to fully control losses and promote efficiency, but economically it is possible to reduce losses by maximizing uses and minimizing technical losses to the least or minimum possible levels. From economic point of view efficiency means optimal uses of natural materials and human resources in the energy sector, (i.e. directing resources to satisfy priority needs which are characterized by least possible costs and maximum possible gains or benefits). (Gamal Osman Abubaker. 1991- Sudan Energy News. 1991, pp.15-18).

According to Gamal Osman (1991), losses and inefficiency in the energy sector naturally attributed to technical problems, but the other socio-economic factors directly or indirectly contributed in raising losses. So in the broader context, the mechanism of solving or reducing losses problem must considers all the primary and secondary factors through introducing and enforcing short - medium and long terms effective solutions or comprehensive plans. The short run plans concentrate on a temporary solutions, through minimization of losses problems at their eliminatory stages, improving operative efficiency of machines and equipment which are related to energy production, transportation and conversion. Medium term plans, should focus on increasing the public or general awareness, in addition to the reform of infrastructural bases (e.g. transport and communication system), and through introducing techniques that help or required in reducing losses problems and promoting allocative and productive efficiency. Moreover, securing funding or finance that are required for the implementation of the medium term projects and plans that are related to losses problems. The implementation of the long term plan (objectives) required a long time period, and greatest finance, since it represents a comprehensive plan at sectoral, regional and national levels. Moreover, ranking priorities and policies according to sectoral, regional and national needs or objectives, introducing techniques which are characterized by lowest fuel consumption, highest operative capacity and efficiency, creating organizing and promoting a comprehensive information system (i.e. information Bank), promoting the infrastructural bases like communication and transportation systems by increasing their operative capacity and efficiency, and concentrating on hydroelectric power generation as a substitute for thermal power generation, because it has low cheapest costs and high efficiency. In addition to, implementation of the relevant economic polices that promote the efficiency and performance of the energy sector and help to save or preserve hard currency, and encourage the involvement or participation of the private sector in enhancing investment efforts in energy sector, the reform of supply side and manpower development (i.e. the enhancement of workers qualification) . (Sudan Energy News. 1991, pp.15-18).

According to Sudan's National Energy plan (1985-2000), improve efficiency through investment in debottlenecking, policy changes and better management of foreign exchange resources, efficiency can be realized in production, consumption of wood, production, transmission, conversion, distribution and transportation of electricity and in the purchase of petrol and transport distribution, (The National Energy Plan 1985-2000) and Sudan Energy News. 1991).

6.2.6 Rationalization of Commercial Energy Consumption through Reducing the Working Days :-

This procedure is pursued in many countries, because reducing the working days from six days to five days help to save or preserve oil fuel consumption (including benzine and gasoil for transport sector), and electricity in public services, commercial and productive sectors, because the reduction of working days will reduce consumption and will help to save or preserve electricity used for lighting, cooling and other offices uses. Moreover, the reduction of working days will lead to a reduction in the consumption of gasoil and benzine in the transport sector. According to Al Zubeir (1991), fuel consumption on Friday (official holiday) is less than consumption in the other working days by 43%.

According to the result of Al Zubeir (1991) statistical survey, benzine total consumption in working days was about 137,000 (gallons), while the total consumption of benzine on Friday was about 78,000 (gallons), therefore saving per week was about 59,000 gallons. The reduction in total consumption of benzine per years was about 3068,000 gallons or 10,200 tons. The results of Al Zubier (1991) statistical survey, indicated that total gasoil consumption in working days was about 168,000 gallons, Friday consumption was about 95,000 gallons, the reduction in total consumption per weak was about 73,000 gallons, and was about 3,866,000 gallons or 14,425 tons per year. Moreover, the study revealed that total saving from electricity per year resulted from the reduction of working days per week was about 6,25 (GWH) or 17 (MWH) which equals 2143 ton of furnace consumption, the study indicated that the total saving of commercial energy (electricity and petrol) per year was about 27,000 ton in Khartoum city and was about 45,000 ton in the Sudan (i.e. in all the country), or was about 3% of total petrol consumption , the cost of which was about 8 million dollars. The study recommended this proposed procedure and directing this saving to satisfy the needs or requirements in the agricultural and industrial sectors which will lead to an increase in the value added in these sectors. Because these productive sectors are faced by shortage in supply, e.g. the NEA studies indicated that shortage of supply in the agricultural sector at critical time in 1983, resulted in a reduction of total supply in the sector by 20 million Sudanese pounds, and total losses in the sector of about 133 million Sudanese pounds.(Al Zubeir .Al-Sayed.Al Zubeir 1991- Sudan Energy News.1991, pp.8-11).

6.3 Microeconomic, Sectoral Strategies:-

6.3.1. Petrol (Oil) Sector :-

Petrol (oil) sector suffers from low supply that fail to cover the growing or increasing demand. Hence, all proposed projects or suggested programmes must focus on strategies of raising supply and reducing demand. Many options are recommended to bring balances in the market and to reduce dependence on oil imports. These include increasing domestic exploitation, reducing the current consumption through raising prices and rationalization procedures, and shifting or switching to the other fuels such as hydroelectric power, coal, geothermal power and encouraging the use of new and renewable sources.

The National Energy Plan (1985-2000), recommended the following programmes: (1) programme of petrol imports facilities to increase the volume of imports by devoting adequate foreign exchange receipts, and co-operating or making contracts with least cost suppliers or producers in oil market, maximizing fuel efficient modes of petrol transparent within the country to minimize losses in storage handling and distribution in the short run; devoting more efforts to increase the volume of oil imports and considering them as a top priorities that deserved highest attention in the total imports list and directing or allocating greatest flows of foreign exchange receipts to increase the volume of oil imports to satisfy the requirements of the productive sectors in the economy particularly agricultural and industrial sectors.

Based on the results obtained in chapter (4) of the present study, petroleum products are necessary inputs for the productive sectors and in most cases have no close substitutes. The income elasticity of aggregate oil products is less than unity and most sectoral demand function showed income and price elasticities less than unity, thus oil products are important or necessary input in the productive sectors in the economy. In the long and medium terms, efforts must be devoted to introduce the relevant techniques to enhance and maximize the exploitation of domestic (indigenous) discovered oil and to remove all constraints that delay exploitation. Moreover, promoting and using the exploitable natural gases (discovered) in thermal electricity generation as a substitute for imported gases product.

According to the National Plan (1985), the long term strategies aim to maximize the use of indigenous resources through maximizing the contribution of indigenous crude oil in the GDP in the economy and through the intensification of exploration and development activities and use remote crude oil deposits, reduce the growth in demand for oil products by maximizing hydro power for electricity generation and build in land refinery capacity and using domestic crude.

For oil sector, demand side management strategy is crucial to achieve the sectoral strategies, the demand side policy include: (1) Determination and ranking priorities in the distribution of oil products, with particular consideration of sectoral needs and the gains or economic rate of return to the economy (GDP),from oil consuming sectors.(2) Reform or adjusting the existing pricing system in petrol sector and the use of other important or effective economic tools or means so as to reflect the real economic and financial costs of supply, with efforts aim to generate profits to General Petroleum Corporation to encourage investment in the agricultural and industrial sectors, to reduce the extravagant consumption to reduce or fill the supply-demand gap. Emphasis on high priorities in sectoral distribution of oil products.(The National Plan.(1985-2000) pp.69-70).

The National Plan (1985), recommended that "pricing policies must consider the relevant economic price for each sector and policies aim to (1) promote the sectoral productivity (e.g. to provide subsidise or low prices of electricity, diesel and furnace for industrial sector - gasoil and diesel for the agricultural sector), (2) reduce the extravagant consumption through imposing imports restrictions or imposing high taxes or both for equipment and machines which are characterized by high oil consumption. (3) promote both technical and economic efficiency through rationalization, regulatory laws and policies and raising general public awareness among final consumers. (4) increase hydroelectricity generation to the maximum level to be used as a substitute for imported oil products, because it is domestic sources and have cheapest low costs compared with high and expensive imported oil products.(5) encourage the uses of new and renewable resources as a substitute for imported oil products in the agricultural, industrial and household sectors. Recently agricultural residues and bagas resources are used in sugar factories as a substitute for oil products (Kenana Sugar Factory uses bagas).(6) Promote and maximize the efficiency in the transport sector which is the largest oil consuming sector(on average uses about 60% of total consumption) through structural reforms or changes to promote technical and economic efficiency in the sector,concentration on public transport rather than private transport and encourage the usage of river and railway transport as a substitute for road transport.(The National Plan.(1985-2000)pp.53-54).

6.3.2 Electricity sector :-

Electricity sector in the Sudan suffers from unreliable supply, excess demand, inefficiency and losses problems. Strategies and plans are recommended to (1) stabilize supply and increase its availability in the critical times (2) reduce extravagant consumption (3) rationalize consumption and enhance demand management strategies, (4) promote efficiency and reduce losses, (5) encourage investment particularly private sector participation.

The National Plan (1985) demonstrated that, "basic trade off exist between satisfying near term demand on highly reliable basis and providing expanded services to the Blue Nile Grids and meeting the growing needs of regional communities".

According to the National plan (1985), the long term strategy for electricity sector aims to cover the excess demand, to increase total generation with least possible costs. These objectives achieved through devoting and securing adequate finance and funding for power generation and transmission facilities in both short and long terms.

According to the National Plan (1985), the short run objectives are focused on controlling consumption pattern and improving supply through the following: (1) Rehabilitate the system and improve over all operative procedures to reduce both technical and non technical losses by 10% of total consumption or 100 (GWH), in addition to increase reliabilities, investment and funds to purchase spare parts for the operating machines and equipment. (2) Eliminate excess consumption and improving tariff system by collecting from all customers. (3) Launching an aggressive conservation and load management programmes to reduce the non essential usage of electricity and expanding the use of economic cost based rates. (4) Directing the limited available supplies to satisfy the highest priorities and uses. (5) Manage the extension of service to new customers so that demand does not exceed the available supply. (6) Use generating capacity of private operators in planning to meet loads in critical periods. (7) Improve management performance and financial ability to enhance the National Electricity Corporation plans of operating electricity corporation effectively without resorting to subsidies. (8) Improve regional electricity generation performance through technical and financial assistance to local governments and increasing or enhancing efforts of regional electrification.

The long term plan aims to maximize the uses of indigenous supplies to provide low costs reliable electricity in a well managed system through: (1) maximize hydroelectric expansion, (2) minimize thermal expansion, (3) exploit non traditional energy sources for the regions like small hydroelectric generation system and remote crude, (4) involve the private sector in financing and managing system expansion, (5) implementation of both short and long terms programmes which are objected to create adequate supply with reliable power generation.

The success of the demand side management strategy requires a comprehensive regulatory laws and rationalization policies, adjustment, reforms and collection of tariffs from different consumers, improve the financial performance, encourage the efficient consumption, commercialize electricity operations, through increasing efficiency, adjusting tariff or prices system through eliminating subsidies and enhancing managerial administrative efficiency on self sustained basis. According to the National Energy Plan (1985), controlling and adjusting of tariff collection system will reduce total consumption by 1.5% of total sectoral electricity consumption in the country.(The National Plan.(1985-2000) p.79). Reforming and adjusting tariff for the household sector i.e. pricing according to final consumption through increase the price per meter as consumption increase after certain threshold or level (i.e. payment according to total final consumption). This implies subsidizing low and medium income groups but taxing high income group (i.e. pricing according to ability to pay). According to the National plan this will save about 1% of total electricity consumption. The plan(1985), recommended other forms or types of tariff such as (1) peak and non peak period tariff i.e. considering prices and costs at peak and non peak periods, issued to or for high income group and consumers in the agricultural, industrial and commercial sectors that are ready to pay and accept this procedure or high tariff to ensure a reliable supply at peak or critical times. The plan(1985), considered them as effective procedures to reduce consumption at peak period but demonstrated that they are of limited use due to the lack of the equipment and machines required for the implementation of these procedures. (2) Average costs pricing system, which was the first pricing policy pursued in the Sudan, it depends on average costs of electricity generation from different sources and consumption per kilo watt hours. However, it is not applicable now. (3) Marginal costs pricing system, recently electricity tariff on Sudan depends on this system, the system considers the costs of short - medium and long terms investments. In this system consumers are obliged to pay for these additional (short, medium and long terms) investments that involve improvement in generating services. Economically the marginal cost pricing system is more acceptable because compared with the other system it reflects the real financial costs of supply. Moreover, long run marginal cost pricing policies cost must consider the increase of petroleum products prices or costs which enter into generation of electricity (e.g. diesel for thermal generation) by equivalent ratio to consider the increase in prices to cover any additional costs in productive sectors. The marginal cost pricing system depends on fixed costs, variable costs (i.e. operation costs) of machines and equipment used in generation process and total costs of generation. (The National Plan.(1985-2000) pp.79-81) and Gamal Osman Abubaker. 1991- Sudan Energy News. January, 1990, pp.21-29).

The National Energy Plan (1985), (1) emphasized the role of public awareness efforts in the household, industrial and agricultural sectors to eliminate or reduce the non essential or non necessary consumption without affecting the productive sectors capacity, these achieved through the reduction of technical losses to about 16 - 20% of total consumption, which will save about 50% of electricity particularly at critical times. (The National Plan.(1985-2000) pp.78-79). Moreover, the National Plan (1985), recommended for the (2) promotion and encouragement of scientific empirical research projects in electricity sector and in energy sector as a whole to determine the magnitude of the crisis and to assess efforts undertaken. (3) Control time of consumption in order to reduce the consumption at peak and critical time period, these aim to transfer demand from peak critical period to non peak (non critical) period on daily or seasonal bases, through introducing the following: (1) introducing pricing differential, reducing prices in non peak period in the industrial, agricultural and commercial sectors, and raising prices in the critical peak period to reduce total electricity demand.

6.3.3 The biomass sector :-

The biomass sector seriously suffers from the problem of excess demand and diminishing supply. The National Plan (1985), recommended the following programmes to alleviate the sector's problem, (1) creation of high level task force which aim to define strategies, programmes and organizations to conserve forests (tackle forestry \ Land use management problem). (2). Rain fed plantation development that aim to increase the supply of wood fuel. (3) Irrigated plantation development to secure the ecological balances. (4) Resources management and conservation management which will enhance the efficient use of existing resources and reduce the non essential demand.

The National Plan (1985), recommended the following: (1) increasing productivity of existing forests resources and efficient utilization of wood being cleared from the agricultural land instead of burning it and raising the efficiency of charcoal production, while protecting or rehabilitating them. (2) Establishing new forests, through planting more forests on rainfed areas and irrigated schemes by enforcing the article 20 (3) of the Forestry Law which specifies 10% of the total rainfed area as protection and production belts, and 5% of the total irrigated area for the same purpose. (3) Encouraging the production of the huge traditional renewable resources of agricultural residues such as groundnut shells and cotton stalks, animals waste (biogas units) and industrial residues in terms of bagass and molasses. (4) Demand management and conservation through improving the technology of stoves (design and dissemination) and awareness efforts . (5). Encouraging the use of alternatives through increasing their supply such as kerosene and liquid petroleum gas (L.P.G).

For biomass sector demand side management strategy and rationalization policies represent a focal point in the proposed sectoral strategies aim to manage the problems of this sector. However, the success of this policy depends on adjusting and reforming pricing system to reflect the real costs that is considered or based on forests costs plus marketing cost, wages of labours working in cutting trees plus marginal profit. Charcoal price is more complicated compared to fuel wood, because its cost includes the cost of techniques of burning (conversion) and labour wages. Recently a small proportion of agricultural and animal residues are used, but they have no clear pricing because they are still in experimental stages and not widely used. (The National Plan.(1985-2000) pp.79-81) and Gamal Osman Abubaker. 1991- Sudan Energy News. January. 1990 pp.21-29).

The proposed pricing system in the charcoal sector according to National Energy Plan, and Gamal Osman (1990), depends on the criterion of marginal cost which includes or considers the costs of investment in the sector, costs of plantation of new trees and costs of replacing traditional techniques used in burning by modern one with high efficient techniques, and costs of new machines used in cutting trees (and replacing hand cutting) which represent fixed costs. (National Energy Plan (1985-2000) and Gamal Osman Abubaker. 1990 pp. 21-29).

6.3.4. The New and Renewable Energy Resources :-

"The new and renewable resources include indigenous hydro-carbon resources, coal, peat, natural gas and renewable energy resources like solar, wind, non wood biomass, small hydro and geothermal. Although these resources are abundant and have great supply, however, they do not significantly contribute in Sudan's energy balance due to under-utilization, under-development of techniques used to exploit these sources, difficulties in application and low economic return of some of them". (The National Plan.(1985-2000) p.65). "In the short run, there is uncertainty about the benefits from these sources, however, in the long run they are expected to contribute significantly in Sudan's energy balance through raising total supply and effectively contribute to meet energy needs". (The National Plan.(1985-2000).

"Supply side strategy aims to maximize energy supply from these indigenous sources as large as possible and to promote the economic uses of these sources. Demand side management strategy aims to use these sources as a substitute for the commercial energy (oil products and electricity i.e. to reduce the pressures on the two sources) and as a substitute for traditional biomass wood fuel and charcoal to reduce the environmental degradation and ecological imbalances".(The National Plan.(1985-2000) p.65). These sources are also suggested to satisfy the need of other far locations which are not supplied by modern energy means. According to National Energy Plan (1995), the short run plan aims to provide motive and direction to fully assess the potential of each energy sources and where appropriate begin development and commercialization. The National plan (1985), recommended that efforts must be directed to explore and develop hydro carbon resources, particularly expanding crude oil and natural gas and recommended that government must initiate interests in these sources and to involve the private sector in all aspects of exploration, development and commercialization, in addition to, more active promotion efforts especially in unsurveyed high potential areas. According to the plan commercialization of renewable techniques implies a complex series of steps that include research, studies, pilot projects and market development, these programmes according to the plan require a sophisticated decision making fund raising to co-ordination, considerable management and organizational skills and creation of renewable implementation task force.

Moreover, at the sectoral, regional and national levels for all energy sources, increasing the efficiency of information programmes help to narrow the gap between the technical potential for energy efficiency and current efficiency levels, because these programmes provide both producers and consumers with information of gains or benefits, losses, impacts ...etc. i.e. the information about the demand side and cover technical, economic and financial information so that they are able to make decisions on energy production and consumption, e.g. provide training information and advice on loss reduction techniques and disseminate information methodology, options and financing.

6.4. Conclusion :-

Since energy problem has constrained the sustainable development objectives and therefore affected the performance of Sudan's economy at both micro and macro levels, thus efforts must be devoted to alleviate the problem in the short run and to minimize or solve the problems in the medium and long runs. A comprehensive plan at the sectoral, regional and national levels must be implemented to solve the fundamental problems. These required the implementation of integral energy strategies which required the improvement of supply side and increase the effectiveness of demand side management strategies, minimization of all forms of losses and maximization of efficiency, ranking priorities, encouragement of conservation strategies to control or to minimize the extravagant consumption. Promotion of both the allocative, economic and technical efficiency. Adjustment and reform of pricing system (i.e. enhancing pricing system efficiency) and using the other economic tools to solve energy problems. Enhancing regulatory laws and implementation of rationalizations policies. Involve the private sector in all aspects of exploration, development, commercialization, financing and managing the energy sector . Facilitate the access to technology, increase the efficiency of information programmes (establishment of information bank) to benefit both the consumers and the producers. Promotion of competitive markets. in energy sector through enhancing market efficiency, establishing stronger autonomous administrative institutions that are capable to carry out or implement energy conservation strategies or programmes in the short - medium and long terms at sectoral, regional and national levels.

CHAPTER SEVEN
THE CONCLUSION AND RECOMMENDATION

Chapter Seven

Conclusions and Recommendations

7.1 Conclusion:-

Energy input plays a vital role for all human, social and economic activities. In the context of sustainable development strategy, energy is essentially considered an important economic factor, because the process of development in the productive sectors is critically determined by or depends on the availability of energy resources, and the growth in GDP directly linked to growth in energy consumption particularly the commercial energy.

The pattern of energy use significantly affects the over all economic performance. In Sudan, the shortage of supply and the excess demand lead to poor economic performance and contributed in the current economic crisis namely shortage of foreign exchange receipts reduces the availability of commercial energy (i.e. petroleum products) which are required for the operation of the productive sectors. Moreover, the pattern of energy use resulted in a serious environmental degradation (like desertification and deforestation) which are serious and hard to manage.

It has been evident that, the growth rate in GDP is directly linked to growth rate in energy consumption, particularly commercial energy. The present study revealed that in the Sudan, both commercial and total per-capita energy consumption are very low and have a very slight growth rate during the study period compared with the other developing countries.

Moreover, the contribution of the energy sector(electricity and water sector) in GDP during the period (1980/81-1990/91) on average was ranged between 1% - 2.3%, the household sector is the major consuming sector and on average accounted for about 76% of total sectoral consumption during the period (1980-1993), this reduced the total amount of energy devoted to the productive sector, particularly, agriculture and industry which accounted for about 3% and 7.2% of total sectoral consumption respectively during the same period.

The present study focused on the analysis of the demand side, the study revealed that energy has an in elastic demand with respect to price and in most cases with respect to income. Most of the estimated equations are statistically significant under the 5% level of significance. All the estimated equations showed a normal demand function because in all the estimated equations the income elasticities are positive. Most estimated equations showed a downward sloping demand curve, some equations showed upward sloping demand curve due to subsidize in prices and because prices did not reflect the real costs of supply(e.g. household demand for biomass, transport sector demand for benzine and gasoil). All the estimated equations showed an inelastic demand functions with respect to price, this implies that energy demand in the Sudan is less responsive to changes in energy prices, and this means that pricing system is inefficient and ineffective in managing or modifying demand pattern during the study period. Most estimated equations showed income elasticities less than unity and this implies that energy is necessary or vital for the consuming sectors in the Sudan.

The results of the present study verified that the volume of imported energy (petrol imports) is significantly constrained by the availability of foreign exchange receipts during the period (1980-1993). This implies that shortage in foreign exchange receipts will directly lead to reduction in the volume of oil imports and therefore affecting the performance of the productive sectors in the economy.

The study revealed that dependence on oil imports as a major commercial energy have a significant implication for the performance of Sudan's economy. The oil imports have positive impacts on GDP through their effects on the performance of the productive sectors. But have serious negative implications on the internal balance, external balance and significantly contributed in raising the rate of inflation.

7.2. Recommendations :-

Based on the results obtained the following recommendations are made:-

7.2.1 The Macro policies, strategies and solutions :-

(1) Enhancement of domestic supply through encouragement of both public and private sectors involvement and participation in energy sector development, through raising hydroelectric power generation and increasing and supporting all efforts devoted toward the exploitation of domestic indigenous oil products and removal of all technical and financial constraints that faced the process of exploitation. Encouragement of scientific research and investment in new and renewable energy resources to fill the shortage in supply.

(2) Implementation of demand management strategies, through controlling demand and reducing it to the minimum possible or acceptable level through regulatory laws and policies, elimination of extravagant consumption and achieving allocative efficiency in the distribution of energy resources, with priority given to the productive sectors.

(3) Increase the awareness among energy consumers (end users) about the gains and benefits obtained from rationalization policies and demand management policies. And support all efforts devoted to implement rationalization and regulatory policies.

(4) Promotion of technical efficiency and reduction of losses to the minimum possible level.

(5) Promotion of allocative efficiency with priority given to the productive sectors.

(6) Adjustment and reform of pricing system to reflect the real costs of supply and to modify the demand pattern in the long run.

(7) Formulation and implementation of short, medium and long terms plans at macro (aggregate) and micro (sectoral) levels.

(8) Consideration of environmental issues in the formulation of energy planning and strategies through encourage the usage of reliable energy sources which are characterized by high technical efficiency and low losses and least possible environmental costs.

(9) Promotion of information system (establishment of information bank).

7.2.2 The Micro (Sectoral) Policies, Strategies and Solutions:-

7.2.2.1 Biomass Sector :-

(1) Implementation of resources management and conservation strategies to achieve the efficient use of existing resources and to reduce or eliminate non essential demand.

(2) Increase the supply of wood fuel through rainfed plantation development projects.

(3) Consideration of environmental and ecological issues through the implementation of irrigated plantation development projects.

(4) Promotion of technical efficiency and reduction of losses to the minimum possible level (particularly losses in conversion) e.g. promotion of efficiency of charcoal stoves (kiln and wood consumption to increase forests productivity).

(5) Reform and adjustment of pricing system to reflect the real costs of production (or supply).

(6) Reduction of total demand and encouragement of shifting toward other new and renewable sources, L.P.G. and kerosene.

7.2.2.2 Electricity Sector :-

(1) Enhancement of electricity generation capacity, concentration on hydroelectric power generation, enhancement of reliability, promotion of efficiency and secure adequate funding for projected schemes and encouragement of private sector involvement and participation in investment in the sector through removal of all technical and financial constraints.

(2) Achievement of allocative efficiency through directing supply to satisfy the productive sectors requirements and reducing the household sector extravagant or non essential electricity usage, through the implementation of energy conservation strategies, demand management strategies, supporting rationalization policies through increasing awareness among consumers (end users) and through the implementation of regulatory laws or policies.

(3) Promotion of technical efficiency and reduction of technical losses.

(4) Reform and adjustment of tariff system to improve financial performance and to encourage efficient consumption (i.e. adjustment of tariff) to reflect the real costs of supply (generation or production).

7.2.2.3. Oil Sector :-

(1) Encouragement of domestic efforts devoted to exploit the indigenous oil production, through removal of all financial constraints, encouragement of private sector investment, involvement and

participation in the process of exploitation, encouragement of foreign investors and facilitate their participation.

(2) Achievement of allocative efficiency through ranking priorities and distributing oil products according to sectoral needs.

(3) Increase the volume of oil imports by directing or devoting more adequate foreign exchange receipts and purchasing at least possible costs through petrol imports facilities.

(4) Promotion of technical efficiency and reduction of losses in production, distribution, conversion and storage; through improvement of efficiency of refinery (Port Sudan refinery generation).

(5) Implementation and encouragement of rationalization policies and enforcement of regulatory laws and policies to reduce non essential needs or consumption through demand management strategies or programmes.

(6) Reform of pricing system (to reflect the real costs of imports or supply) through the adjustment of prices and removal of subsidies.

(7) Encouragement of inter-fuel cross substitution e.g. substitution of expensive imported oil by cheapest domestically produced hydroelectric power generation.

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The Appendix

Table(3-1)

Total and Per-capita Energy and Commercial Enregy and GDP Per-capita in the Sudan (1973 - 1994) Measured in (000) (TOE), (TOE) and (LS)

Item Year	Total Energy Consumption	Total Commercial Energy consumption	Total Energy Per-capita consumption	Commercial Per-capita Consumption	Per-capita GDP
1973	4596.5	842.2	.31	.033	n.d*[1]
1980	4964373	1295220	.278	.073	335.91
1981	4967777	1196941	.271	.066	341.06
1982	5148908	1273573	.274	.068	334.044
1983	5234079	1251421	.252	.060	292
1984	5400812	1309937	.252	.061	251.41
1985	5622665	1422520	.254	.064	268.64
1986	5820783	1508211	.255	.066	273.93
1987	6141650	1546108	.261	.066	259.37
1988	6395967	1514098	.264	.063	279.93
1989	6333221	1521518	.261	.061	265.0
1990	6533221	1784373	.266	.069	259.59
1991	6865539	1711747	.262	.064	280.20
1992	6950747	1697747	.259	.062	308.27
1993	7068747	1708772	.290	.069	356.49
1994	7522107	1846107	.294	.072	381.119

Source : (1) Energy Hand Books (1987, 1990, and 1991) Columns(1) and (2)

(2) Own Calculations Columns(3) and (4) Depending on Columns(1) and (2)

(3) Own Calculations Column(5) Depending on "The Economics Survey" data (1990-1995).

(*)[1]No data.

Table (3-2)
Total Energy Consumption By Type (1964-1996)
Measured in (000) (TOE)

Type Year	Petroleum	Electricity	Biomass	Total Consumption
1964	534.3	35.8	537.3	1107.4
1970	640.3	104.8	3433.7	4178.8
1973	704.9	137.3	3754.2	4596.5
1980	1240984	54236	3669154	4964373
1981	1138566	58375	3770836	4967777
1982	1215388	58185	3875335	5148908
1983	1171741	79680	3982658	5234079
1984	1221644	88293	4090875	5400812
1985	1322423	100097	4200145	5622665
1986	1403552	104659	4312572	5820783
1987	1451978	94130	4595542	6141650
1988	1430728	83370	4881869	6395967
1989	1419118	102400	5011703	6533221
1990	1584472	199900.4	5081166	6865539
1991	1450103	261643.8	5239000	6950747
1992	1409342	288404.7	5371000	7068747
1993	1390705	318067.3	5522000	7230772
1994	1494992	351115.4	5676000	7522107
1996	1654000	293000	6514000	8461000

Source:(1) Energy Hand Book (1987,1990 and 1991).

(2) Statistical Publications(Ministry Of Energy and Mining)

(3) Own Calculations(Rows (15) - (20) Columns(1), (2) and (4)) dpending on statistical publications Ministry of Energy and Mining

Table (3-3)
Forecasts projection and Expectation of Total Energy Consumption in Sudan (1996-2010)
Measured in(000) (TOE)

Type Year	Electricity	petrolueme	Biomass	Total Energy Consumption
1996	293	1654	6514	8461
1997	331	1760	6196	8287
1998	373	1872	6389	8635
1999	435	1992	6587	9014
2000	508	2120	6791	9419
2001	551	2256	6961	9768
2002	599	2407	7135	10141
2003	650	2602	7313	10565
2004	706	2734	7572	11012
2005	770	2916	7711	11397
2006	824	3110	7873	11818
2007	904	3318	8040	12262
2008	979	3538	8208	12725
2009	1062	3778	8381	13221
2010	1153	4031	8557	13941

Source :Ministry of Energy and Mining National Energy Administration (NEA)

Table (3-4)
Total Supply Of and Demand for Energy Type (1981-1993)
Measured in Million(TOE) and (%)

Year / Item	1981	1983	1984	1987	1989/90	1992/1993	1993/94
Total supply	9.7 (MTOE)*			10 (MTOE)	>10 (MTOE)	11.677 (MTOE)	11.139 (MTOE)
Biomass	85 . 6%	82%		84%	82%	87%	86%
Hydroelectric	1. 9%	4%		3%	1%	1%	1%
petroleum	12.5%	14%		13%	12%	12%	13%
Total Demand	6.1 (MTOE)		5.6 (MTOE)	6. 1 (MTOE)	< 6 (MTOE)	6. 653 (MTOE)	7. 381 (MTOE)
Biomass	82%	82%	81. 4%	81. 8%	81%		
Hydroelectric	1%	1%	1. 1%	1.0%	2%		
petroleum	18%	17%	17. 5%	17. 2%	17%		
Total Losses	3.6 (MTOE)			4 (MTOE)	> 4 (MTOE)	5. 024 (MTOE)	3.758 (MTOE)
Supply - Demand -Gap		3%		4. 2%	6%		

Source : Energy Hand Books (1987,1990 and1991)

*** MTOE represent Million (TOE)**

Table (3-5)
Sectoral and Total Electricity Consumption and Generation (1985-1994) Measured In (GWH)

Sector Year	Total consumption	House Hold consumption	Industrial consumption	Agricultural consumption	Other sector consumption	Total Generation
1985	1173.19	738.62	300.16	23.38	111.03	1266
1986	1217.04	693.82	374.55	27.65	96.77	1349.58
1987	1094.58	530.15	420.39	24.76	97.38	1432.8
1988	969.42	518.36	308.46	27.83	92.01	1277.73
1989	1050	541	190	207	112	1754
1990	1240	728	184	195	133	1882
1992	1789	1054	279	304	152	1573.585
1993	1973	1148	313	349	163	1683.1
1994	2178	1250	352	400	176	1858.73
1993 - 1994 Growth Rate	-	6.6%	5.6%	10.6%	6.3%	6.7%

Source : (1) The Economics Survey (1989/1990-1994/1995) and
(2) Energy Hand Books"1987,1990 and 1991").

Table (3-6)
Total Expenditures on Energy Sector (1981-1994)
(Measured In Million (LS)) and (%)

Item Year	Total Sectoral Expenditures	Total Expenditures on Energy Sector	Percentage of Energy Expenditures To Total Expenditures
1981	306,4	58.8	19.2%
1982	394,1	62.1	15.8%
1983	434,4	74.3	17.1%
1984	419,1	72.1	17.2%
1985	333,8	35,7	10.7%
1986	1233.3	263,3	23.1%
1987	1208,4	253,3	20.96%
1988	1413,0	238,6	16.9%
1989	1722,5	233,8	13.6%
1990	2316,8	425,4	18.5%
1991	10004,2	1018,5	10.18%
1992	27705,4	4501,4	16.25%
1993	14093,0	719,0	5.1%
1994	12812,0	149,0	11.62%

Source :(1) The Economic survey (1989/1990 - 1994/1995) Columns(1) and (2)
(2) Own Calculations Column(3) depending on Columns(1) and (2)

Table (3-7)
Energy Consumption By Sectors (1978-1993)
Measueed In (%)

Sector Year	Agricultural sector	Industrial sector	transport sector	House.Hold Sector	Public Services and commercial sector
1978/1979	3.6%	45.9%	*	41.3%	4.5%
1980	*	*	*	*	*
Biomass	3%	*	*	95%	3%
Electricity	11%	36%	*	39%	16%
petroleum	*	*	57%	*	*
1981	*	5.8%	11%	77.8%	*
1982	3%	8%	9%	75%	4%
1983	3%	8%	9%	75%	4%
Biomass	*	20%	*	98%	27%
Electricity	11%	8%	*	*	6%
(**)				44%	
Petroleum	3%	45%	*	*	4%
1984	2.7%	4.5%	10.9%	77.2%	3.8%
Biomass	*	47%	*	77.5%	4.27%
Electricity	*	8%	*	*	6.45%
(**)				93%	
Petroleum	*	45%	*	*	3.96%
1987	3.5%	10%	10%	72%	3%
Biomass	*	50%	*	80%	80%
Electricity	*	*	*	<20%	*
Petroleum	*	*	*	3%	*
1989	3%	<7%	10%	>77%	3%
Biomass	3%	44%	*	93%	*
Electricity	3%	<8%	*	60%	10%
petroleum	98%	57%	60%	*	*
1990	*	*	*	*	*
Biomass	3%	*	*	95%	3%
Electricity	3%	30%	*	66%	10%
Petroleum	*	*	*	*	*
1992	3%	6%	11%	>77%	3%
1993	3%	7%	10%	>77%	4%
Biomass	*	54%	*	93%	9.1%
Electricity	*	*	*	51%	5%
Petroleum	*	*	64%	*	4%

Source : Energy Hand Book (1989.1990 ,1991).
(*)No informations available.
(**)Total Commercial Energy(Electricity+Petroleum)

Table (3- 8)
Total and Per-capita Electricity Consumption and Production(Generation) (1980-1994) Measured in (KWH) and (GWH)

Item Year	Total Production (Generation)	Total consumption	Per-capita Production	Per-capita consumption
1980	787.34	630.65	44.714	35.366
1981	897.54	678.89	49.089	37.135
1982	954.53	659.32	50.894	35.159
1983	1025.41	926.51	49.353	44.593
1984	1227.67	1026.66	57.295	47.914
1985	1266	1173.19	57.285	53.086
1986	1349	1217.04	59.182	53.393
1987	1432.8	1094.58	60.944	46.558
1988	1277.73	969.42	52.701	39.984
1989	N.A	1050	N.A	42.00
1990	N.A	1240	N.A	48.109
1991	1573.585	1623	59.222	61.082
1992	1683.1	1789	56.601	65.476
1993	1858.73	1973	67.486	79.120
1994	1855.83	2178	72.621	85.095

Sources : (1)Energy Hand Books 1987 , 1990 and 1991
(2)Natinal Electricity Corporation (NEC) publication
(3) Columes (3) and (4) Own calculations depending on Columns (1) and (2)
(4) N.A (No avilable Information)

Table (5-1.d)
Total Petroleum Products Consumption By Sectors (1980-1995) Measured in (MT)

Sector Year	Agricultural Sector consumption	Industrial Sector consumption	Transport Sector consumption	Household Sector consumption	Total Sectoral consumption
1980	228794.7	101417.6	525301.6	6942.1	968866
1981	243737.5	108019.2	559494.9	25238.2	1029114
1982	251808.4	138089	610964.1	14526.7	1048315
1983	137370	186981	607294.8	25110	1123040
1984	67550	169817	616960.3	19852	1072082
1985	186743	171017	701674.1	19408	1186925
1986	185092	196721	733549.2	27285	1346122
1987	263819	195425	764816.0	73968	1358265
1988	203680	169010	779255.3	31828	1425400
1989	189567	184524	743237.9	33147	1360396
1990	195071	661483	778631	29227	1664412
1991	214833	380172	697478	29930	1322389
1992	156067	387843	782599	25880	1352389
1993	209261	340635	763045	18779	1331720
1994	407335	509173	694284	19360	1630152
1995	204483	382871	703841	18899	1310094

Sources : (1) Energy Hand Books (1987,1990 and 1991)
(2)Ministry of Energy and Mining (Petroleum Statistics Unit- National Energy Administration).

Table (5-2)
Total Petroleum Products Consumption in The Sudan Measured in (MT) (1980-1995)

Year	Diesel	JET-AI	Benzine	Gas-oil	Furnace	Kerosene	Avagas	L.P.G	Total Petroleum Products consumption
1980	20407	47628	190951	510553	170502	17626	6090	5109	968866
1981	18334	41779	212247	539972	186603	20391	4074	5714	1029114
1982	21683	52749	202504	560904	188792	10996	4525	6162	1048315
1983	32700	63290	208680	567587	221563	17195	4154	7871	1123040
1984	30118	63984	182415	536771	235206	13247	3309	7032	1072082
1985	25243	79144	186168	606465	266063	12302	3676	7564	1186925
1986	30299	83223	216996	633466	350017	17943	4454	9724	1346122
1987	38624	79060	236772	663950	313116	14579	2325	9839	1358265
1988	43000	76000	240000	748000	283000	22000	3200	10200	1425400
1989	41325	75993	223276	714337	268941	23790	2157	10577	1360396
1990	157416	73735	234131	772349	254691	17241	1119	12849	1523531
1991	34475	71133	178274	813054	264332	17981	2232	12849	1394330
1992	38275	71133	210648	752183	254122	13284	2232	13260	1355137
1993	35883	92674	208882	774558	205187	7000	893	12139	1337216
1994	37224	85038	202928	716368	373090	9208	1145	12491	1437492
1995	45641	79509	183614	753291	340393	3760	1628	15197	1423033

1) Ministry of Energy and Mining (Petroleum Statistics Unit- National Energy Administration)
(2)Energy Hand Book (1990-1991)

Table (5-3)
Forecasts projection and Expectation of Total Petroleum Products Consumption in TheSudan (1996-2010) Measured in (000) (TOE)

Type Year	Avagas	Benzine	Gas-oil	Furnace	Kerosine	Jet -AI	L.P.G	Total Petroluem Products consumption
1996	3	211	842	452	42	78	26	1654
1997	3	221	909	475	43	82	27	1760
1998	3	232	982	449	44	86	27	1873
1999	3	242	1060	524	45	90	28	1992
2000	3	253	1145	550	46	95	28	2120
2001	3	263	1237	577	47	100	29	2256
2002	4	279	1336	606	48	104	30	2407
2003	4	293	1442	636	49	110	31	2602
2004	4	307	1558	668	51	115	31	2734
2005	4	323	1682	702	52	121	32	2916
2006	4	339	1817	737	53	127	33	3110
2007	4	356	1962	774	55	133	34	3318
2008	4	373	2119	812	56	139	35	3538
2009	4	392	2289	853	57	147	36	3778
2010	4	411	2472	895	59	154	36	4031

Source: Ministry of Energy and Mining (National Energy Administration)

Table (5- 4)
Petrol Imports and Total Imports (1980 - 1994).
Measured in Million (LS) and (%)

Item Year	Total Imports	Petrol Imports	Petrol Imports/ Total Imports	Impotrs (2) Total Imports- Petrol Imports	Imports (2)/ Imports(1)
1980	788.2	169.646	21.52%	618.6	78.48%
1981	866.7	168.3	19.41%	698.4	80.58%
1982	1213.8	328.8	27.08%	885	72. 91%
1983	1760.9	448.0	25.44%	1312.9	74.558%
1984	1803.7	409.1	22.68%	1810.4	77.318%
1985	2128.8	318.4	14.96%	2109.9	85.04%
1986	2402.2	292.3	12.168%	2115	87.83%
1987	2612.9	497.9	19.055%	3799.7	80.94%
1988	4892.8	1093.1	22.34%	4291.2	77.659%
1989	5373.4	1082.1	20.14%	3291.2	79.86%
1990	618.5	312.3	50.49%	306.2	49.51%
1991	890.3	308.757	34.67%	581.243	65.32%
1992	820.3	229.645	27.97%	591.253	72.03%
1993	944.9	215.253	22.77%	729.679	77.22%
1994	1161.5	239.0	20.57%	922.5	79.42%

Sources : (1) Bank of Sudan Annual Reports (1980-1994).(Columns(1) and (2)).
(2) Columns (3),(4)and (5) Own Calculation dependig on Columns (1) and (2).

Table (5- 5)
Petrol Imports and Total Exports (1980 - 1994).
Measured in Million (LS) and (%)

Item Year	Total Export	Petrol Import	Petrol Import / Total Export	Total Import/ Total Export	Total Export/ Total Import
1980	271.3	169.646	62.563%	291%	34%
1981	357	168.3	47%	243%	41%
1982	483.1	328.8	68%	251%	40%
1983	810.7	448.0	55%	217%	46%
1984	817.3	409.1	50%	221%	45%
1985	844.7	318.4	38%	252%	40%
1986	833.2	292.3	35%	288%	35%
1987	1497.1	497.9	33%	175%	57%
1988	2290.9	1093.1	48%	214%	47%
1989	3023.1	1082.1	36%	178%	56%
1990	374.1	312.3	83%	165%	60%
1991	305	308.757	101.23%	292%	34%
1992	319.3	229.645	72.9%	257%	39%
1993	417.3	215.253	52%	226%	44%
1994	523.9	239.0	46%	222%	45%

Sources : (1) Bank of Sudan Annual Reports (1980-1994).
(2) Columns (4),(5)and (6) Own Calculations, depending on Columns (1), (2) and (3)

Table (5- 6)
Petrol Imports Total Imports,Total Exports Trade Deficit and Balance Of Payments Deficit Measured in Million (LS) and (%)(1980-1994)

Item Year	Total Export	Total Import	Trade Deficit	Petrol Import	Deficit(2[1])/ Trade Deficit	Petrol Import/ Trade Deficit	Total Export/ Trade Deficit	Petrol Import/ BOP
1980	271.3	788.2	519.9	169.646	67%	33%	52%	231%
1981	357	866.7	509.7	168.3	67%	45%	70%	50%
1982	483.1	1213.8	730.7	328.8	55%	45%	66%	131%
1983	810.7	1760.9	950.2	448.0	53%	47%	85%	258%
1984	817.3	1803.7	986.4	409.1	59%	41%	83%	564%
1985	844.7	2128.8	1284	318.4	75%	25%	66%	220%
1986	833.2	2402.2	1569	292.3	81%	19%	53%	486%
1987	1497.1	2612.9	1115.8	497.9	55%	45%	134%	71%
1988	2290.9	4892.8	2601.9	1093.1	58%	42%	88%	352%
1989	3023.1	5373.4	2350.3	1082.1	54%	46%	129%	1196%
1990	374.1	618.5	224.4	312.3	[2](*)	1.28%	153%	410%
1991	305	890.3	585.3	308.757	47%	53%	152%	305%
1992	319.3	820.3	501.6	229.645	45%	46%	64%	395%
1993	417.3	944.9	527.6	215.253	59%	41%	79%	577%
1994	1191.5	1161.5	637.6	239.0	63%	37%	82%	1343%

Sources :(1) Bank of Sudan Annual Reports (1980-1994).(Columns (1),(2),(3)and (4))
(2) Columns ((5)-(8)) Own Calculations

[1](1)Deficit (2) = Trade Deficit - Total Petrol Imports
[2](*) Budget Surplus

Table (5- 7)
Total Development Expenditures ,Energy and Petrol Imports Expenditures (1989-1993)
Measured in Million (LS) and (%)

Year /Item	1989	1990	1991	1992	1993
Total Expenditure	2957. 1	4814. 9	7851. 041	3523. 001	5686. 400
(a) Total Foreign Expenditures	1266	1845.7	4592.226	1623.002	1660.700
(b) Total Sudanese Expenditures	1691.1	2969.2	3297.815	1899.999	3461.400
Total Energy Expenditures	209	347.7	1284.231	437.889	1134.300
(a) Energy Foreign Expenditures	119.7	263.5	972.796	126.890	134.300
(b) Energy Sudanese Expenditures	89.3	84.2	311.434	310.999	1000.000
Petrol Expenditures	301.6	367.8	308.757	229.645	215.253
Energy Expenditures/Total Expenditures	7. 067%	7. 22%	16. 57%	12. 429%	19. 947%
Energy Foreign Expenditures /Total Foreign Expenditures	9. 45%	14. 28%	21. 18%	7. 82%	8. 09%
Petrol Expenditures/ Total Expenditures	10. 19%	7. 64%	3. 93%	6. 52%	3. 78%
Petrol Expenditures /Total Foreign Expenditures	23. 823%	19. 93%	6. 72%	14. 15%	12. 96%
Total Expenditures-petrol Expenditures	2655. 5	4447. 1	7542. 284	3293. 359	5471. 147
Total Foreign Expenditures-Petrol Expenditures	964. 4	1477. 9	4283. 943	1393. 356	5471. 147
Total Expenditures-petrol Expenditures/ Total Expenditures	89. 8%	92. 4%	96. 1%	93. 5%	96. 15%
Total Foreign Expenditures-Petrol Expenditures/ Foreign Expenditures	76. 17%	80. 07%	93. 29%	85. 85%	87. 04%
Budgt Deficit	3549	(540)*	22929	25229. 6	7230. 8
Deficit(2) : Budget Deficit - Petrol Expenditures	3247. 4	(907. 8)*	22620. 24	25000. 35	7015. 547
Petrol Expenditures / Budget Deficit	8. 498%		1. 3465%	. 91%	2. 9768%
Deficit(2) / Deficit	91. 5%		98. 65%	99. 08%	97. 023%

Sources :(1) The Economic Survey 1989,1990,1991,1992and1993 (Rows 1-7 and Row 16).
(2)Own Calculation(Rows 8-15, and Rows 17-19). (*)Budget Surplus.

Table (5- 8)
Petroleum Imports Growth Rate and GDP Growth Rate (1980-1992)
Measured in (%)

Item Year	GDP	Petrol Import	GDP Growth Rate	Petrol Import Growth Rate
1980	5990	169.646	2. 81%	136%
1981	6236	168. 3	4. 6%	-99%
1982	6264	328.8	-2. 7%	95%
1983	6084	448	-2. 9%	-86%
1984	5387	409.1	-11. 5%	813%
1985	5937	318.4	10. 2%	-22%
1986	6244	292.3	4. 9%	56%
1987	6276	497.9	-1. 5%	120%
1988	6628	1093.1	5. 6%	-1%
1989	6614	1082.12	-. 2%	-71%
1991	7447	308.757	11. 3%	-26%
1992	8423	229.645	12. 3%	-6%

Sources : (1)"Bank of Sudan- Annual Reports"(1980-1994) and "The Economic Survey" (1989-1994).(Columns(1),(2)and (4).
(2) Own Calculation (Columns (3) and (5))Depending on the Columns (1), (2) and (4)

Table (5-9)
Petroleum Imports Growth Rate and Inflation (CPI Growth Rate)Growth Rate (1980-1992)
Measured in (%)

Item Year	CPI	Petrol Imports	CPI Growth Rate	Petrol Imports Growth Rate	Petrol Rate/ CPI Rate
1980	503	169.65	26.1%	136%	5%
1981	923.4	168. 3	23.9%	-99%	-4%
1982	787.1	328.8	26.2%	95%	4%
1983	1031.7	448	31.1%	-86%	-3%
1984	1367.2	409.1	32.5%	813%	25%
1985	1999.6	318.4	46.2%	-22%	-. 5%
1986	2580.8	292.3	29.1%	56%	2%
1987	3226.3	497.9	25%	120%	5%
1988	4762.8	1093.1	47.6%	-1%	-. 02%
1989	8094.4	1082.2	70%	-71%	-1%
1991	300	308.757	120.5%	-26%	-. 2%
1992	658.6	229.645	119.5%	-6%	-. 05%

Sources:(1)Columns (1) ,(2), (3) Bank of Sudan Annual Reports (1980-1994) , The Economics Survey(1990-1994) .
(2)Columns (4), and(5) Own Calculations Depending on Columns(1), (2) and(3).

Table (5-10)
Energy Consumption Growth Rate,Inflation and GDP Growth Rate Measured in (%) (1981-1988)

Item Year	Petrol Growth Rate	Electricity Growth Rate	Biomass Growth Rate	Total Energy Growth Rate	CPI Growth Rate	GDP Growth Rate
1981	- 9%	7. 09%	2. 70%	0. 07%	23. 9%	4. 6%
1982	6. 3%	-. 33%	2. 70%	3. 520%	26. 2%	-2. 7%
1983	- 3 . 72%	26. 98%	2. 69%	1.63%	31. 1%	-2. 9%
1984	4. 08%	9. 76%	2. 65%	3. 09%	32. 5%	-11. 5%
1985	7. 62%	11.79%	2. 60%	3,95%	46.2%	10. 2%
1986	5. 78%	4. 36%	2. 61%	3. 4%	29. 1%	4. 9%
1987	5. 22%	-11. 19%	6. 16%	5. 22%	25%	1. 5%
1988	-1. 49%	-12. 91%	5. 92%	4. 02%	47. 6%	5. 6%

Source : (1) The Economic Survey (1980-1990) Columns (5) and (6)
(2) Own Calculations Columns (1), (2) , (3) and (4) Depending on data from Energy Hand Books" (1987,1990 and1991) and Statistical Publication from "Ministry of Energy and Mining"

Table(5 -11)
Petrol Imports, Total Imports ,Total Exports, GDP, Inflation (CPI Growth Rate), Balance Of Trade Deficit and Balance Of Payments Deficit Growth Rate (1980-1992) Measured in (%)

Item Year	Petrol Growth Rate	Imports Growth Rate	Exports Growth Rate	GDP Growth Rate	CPI Growth Rate	Balnce Of Trade Deficit Growth Rate	Balance Of Payments Deficit Growth Rate
1980	136%	65.1%	16. 6%	2. 81%	26. 1%	106. 43%	- 188. 98%
1981	-99%	10%	31. 6%	4. 6%	23. 9%	- 1. 39%	361. 85%
1982	95%	40.1%	35%	-2. 7%	26. 2%	43. 36%	26. 22%
1983	-86%	45.1%	67. 8%	-2. 9%	31. 1%	30. 04%	- 30. 51%
1984	813%	-15. 3%	. 8%	-11. 5%	32. 5%	3. 81%	- 58. 29%
1985	-22%	18%	4. 1%	10. 2%	46. 2%	30. 17%	10%
1986	56%	12. 8%	- 1. 4%	4. 9%	29. 1%	22. 20%	- 58. 68%
1987	120%	8. 8%	79. 7%	1. 5%	25%	- 28. 88%	- 1069%
1988	-1%	87. 3%	53%	5. 6%	47. 6%	133. 19%	- 55. 69%
1989	-71%	9. 8%	32%	-. 2%	70%	- 9. 67%	70. 88%
1991	-26%	43. 9%	-18. 5%	11. 3%	120. 5%	139. 48%	33. 11%
1992	-6%	-7. 8%	4. 7%	12. 3%	119. 5%	- 14. 3%	- 42. 65%

Sources : (1) Columns (2), (3) (4) and(5) Bank Of Sudan Annual Reports (1980-1994) "TheEconomics Survey" (1990-1994)

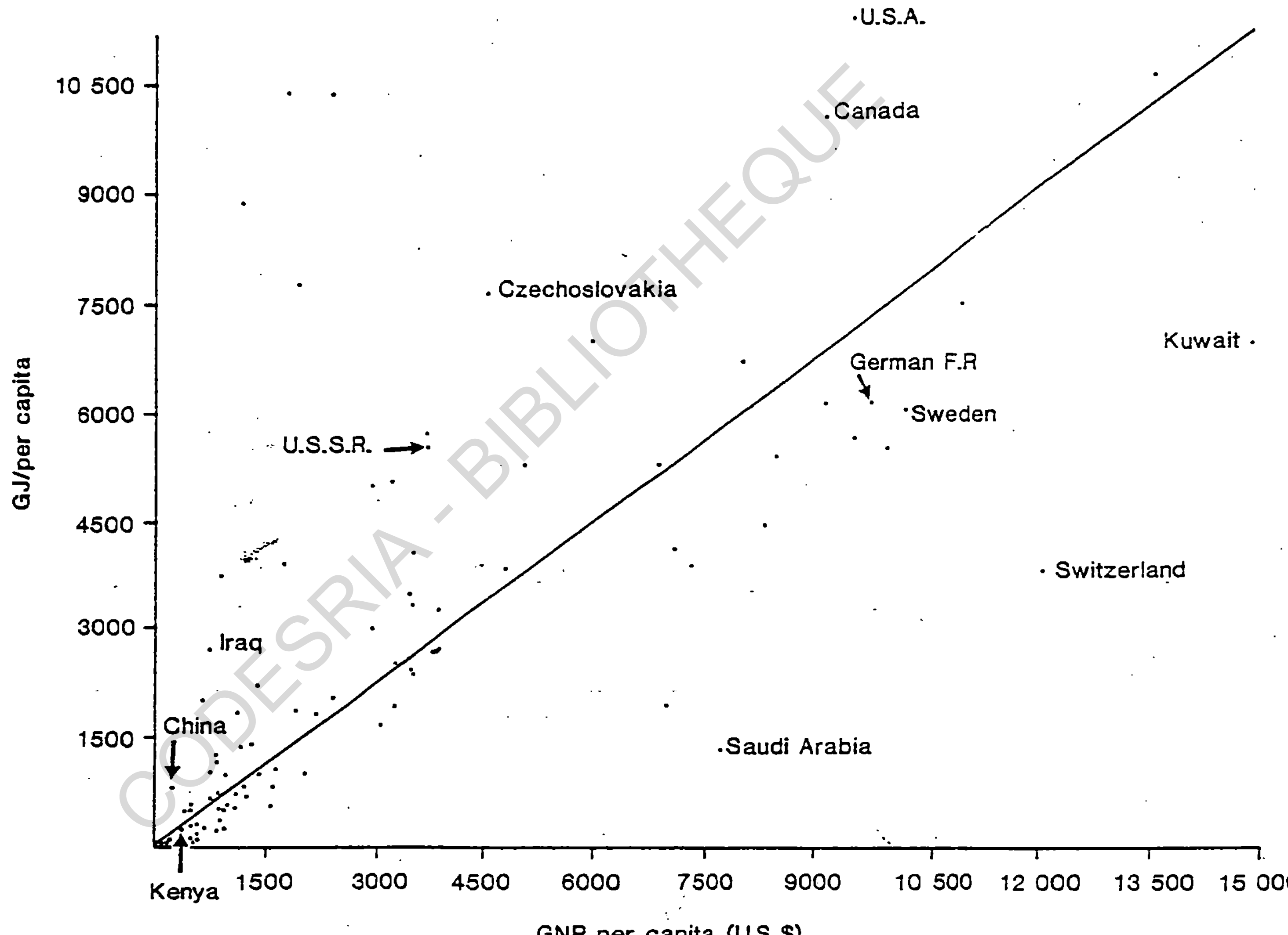
(2) Columns (1) ,(6) and (7)Own Calculations Depending on the above two sources.

Table (5-12)
Petrol , Elecricity and Biomass Consumption and Total Energy Consumption (1980-1989) Measured in (%)

Type Year	Petrol consumption / Total Energy	Electricity consumption / Total Energy	Biomass consumption / Total Energy
1980	. 2499	. 0109	. 7391
1981	. 2299	. 0117	. 7591
1982	. 2360	. 0113	. 7527
1983	. 2238	. 0152	. 7609
1984	. 2262	. 0163	. 7575
1985	. 2352	. 0178	. 7470
1986	. 2411	. 0179	.7409
1987	. 2364	. 0153	. 7483
1988	. 2236	. 0130	. 7634
1989	. 2172	. 0156	. 7671

Source : Own Calculations depending on Information obtained from Energy Hand Book (1987, 1990 and 1991)

Figure 2.1 Relationship of Energy to Economic Output

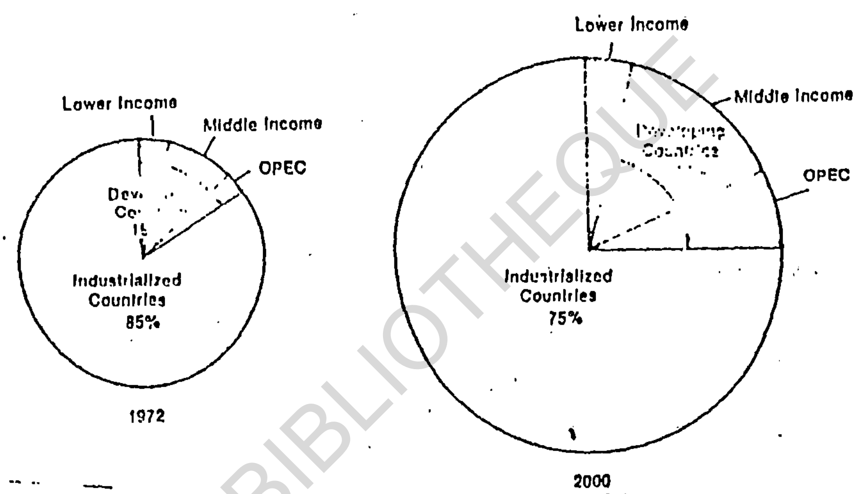


Source: World Bank, 1978

Phil, O'Keef, et al. "Energy, Environment and Development in Africa 1(EEDA 1) Energy and Development in Kenya: Opportunities and constraints".Chap.(2)Pp.8

Figure (2.2)

Projected Shares of the World's Energy Consumption



Source: Waes, 1977.

Source; Waes, 1977.

(Leonard Berry, and Richard Ford(1978). " Fuel Wood and Energy in Eastern Africa; An Assessment of the Environmental Impact of Energy Uses" Adraft Report Prepared on behalf of AID Contract, AID/ Afr-G-1356. Eastern Africa Environmental Trends Project Program For International Development (EAETPP).PP.4

Figure(3.1.a) Total and Commercial Energy Consumption Measured in(000) (TOE) (1980-1989)

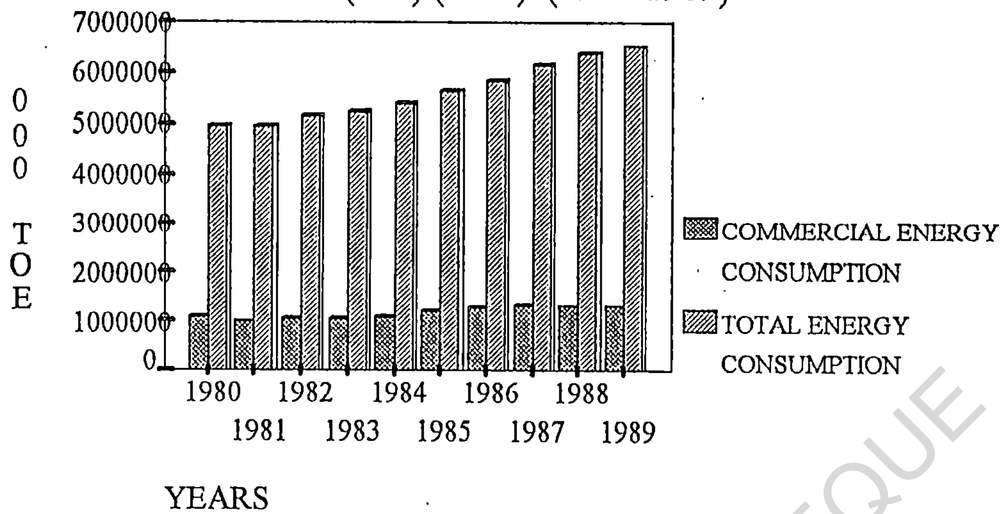
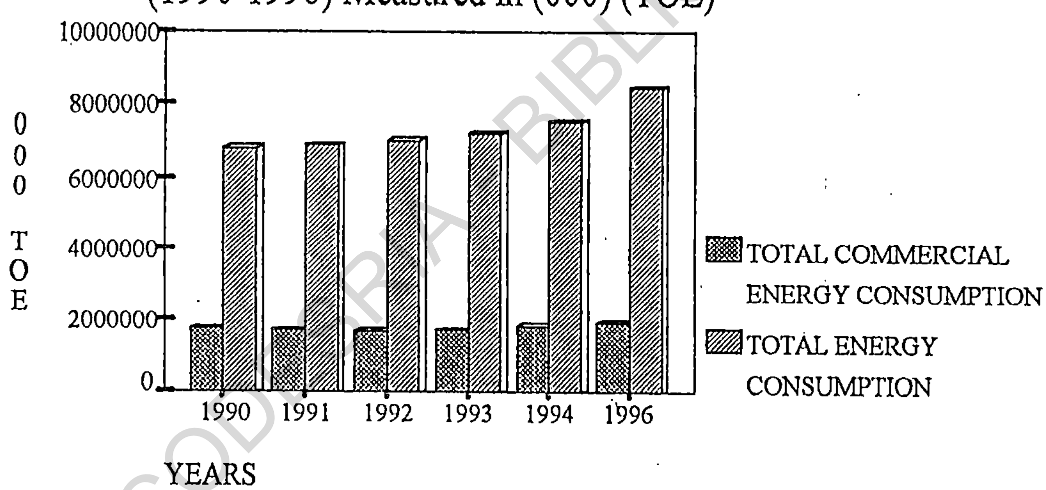


Figure (3.1.b) Total and Commercial Energy Consumption (1990-1996) Measured in (000) (TOE)



Figure(3.1.c) Per-capita Commercial and Total Energy Consumption(1980-1989) Measured in (TOE)

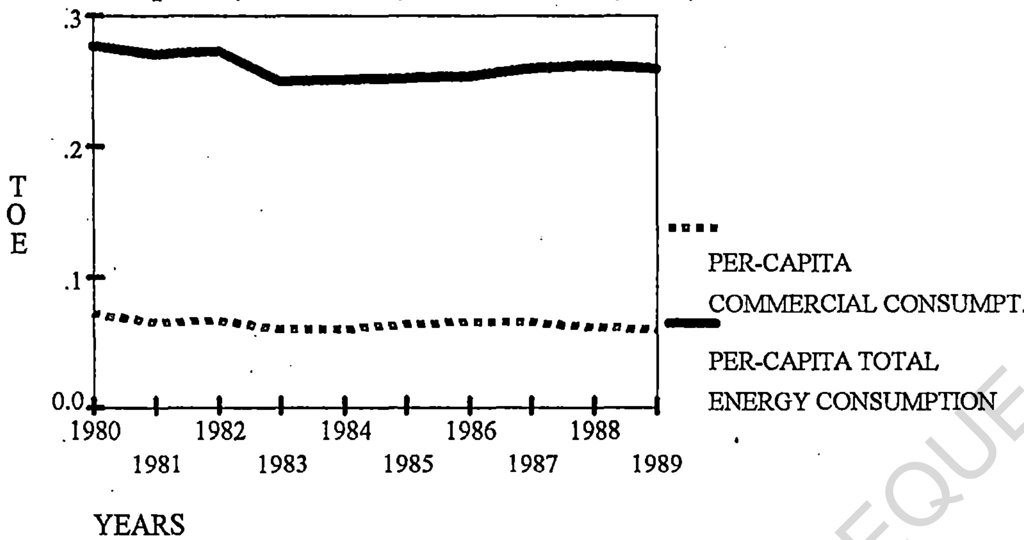


Figure (3.1.d) Per-capita Commercial and Total Energy Consumption (1990-1994) Measured in(TOE)

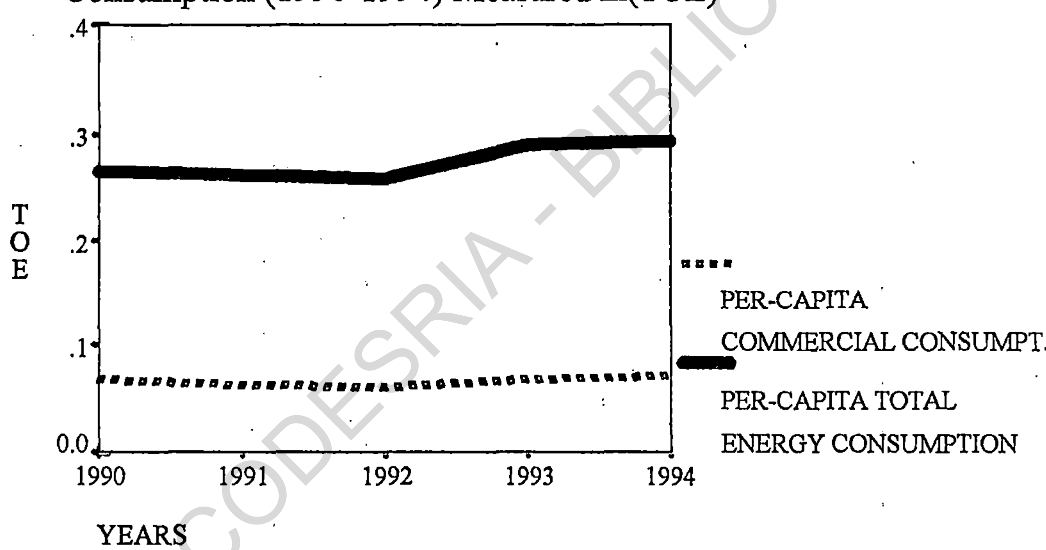


Figure (3.2.a)Total Energy Consumption by Type

(1980-1989) Measured in(000)(TOE)

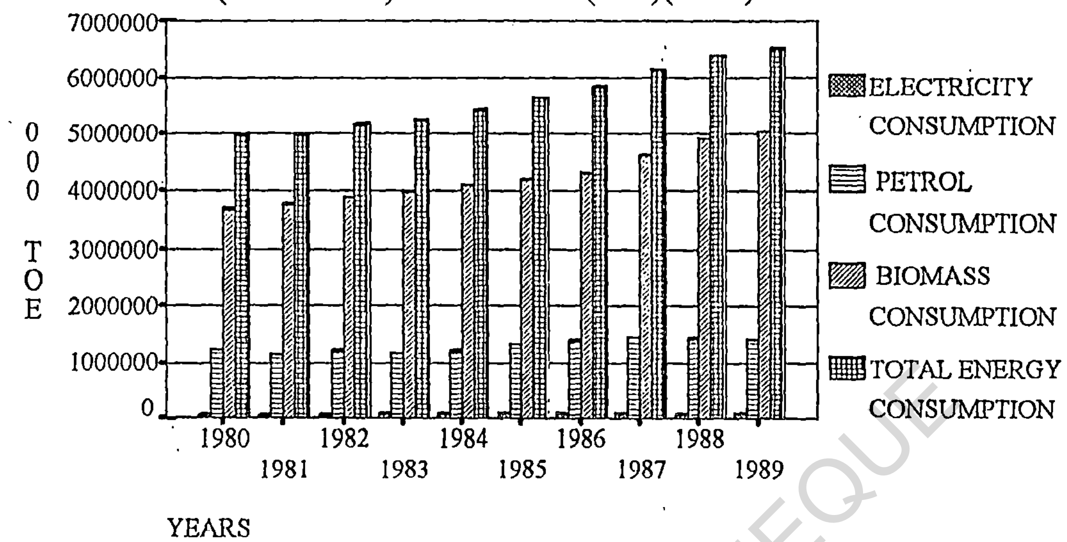
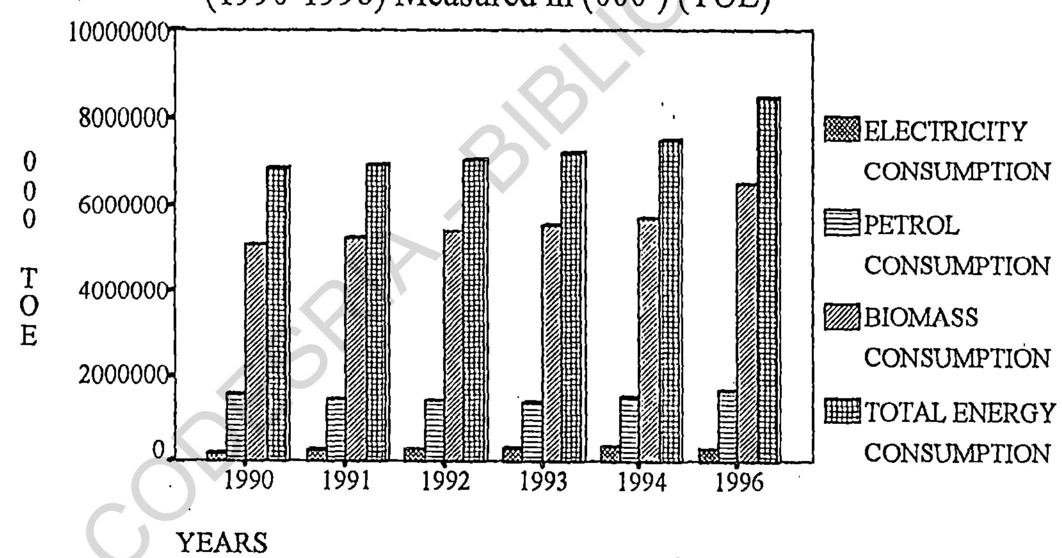


Figure (3.2.b)Total Energy Consumption By Type

(1990-1996) Measured in (000) (TOE)



Figure(3.2.c)Average Energy Consumption By Type (1980-1989) Measured in(%)

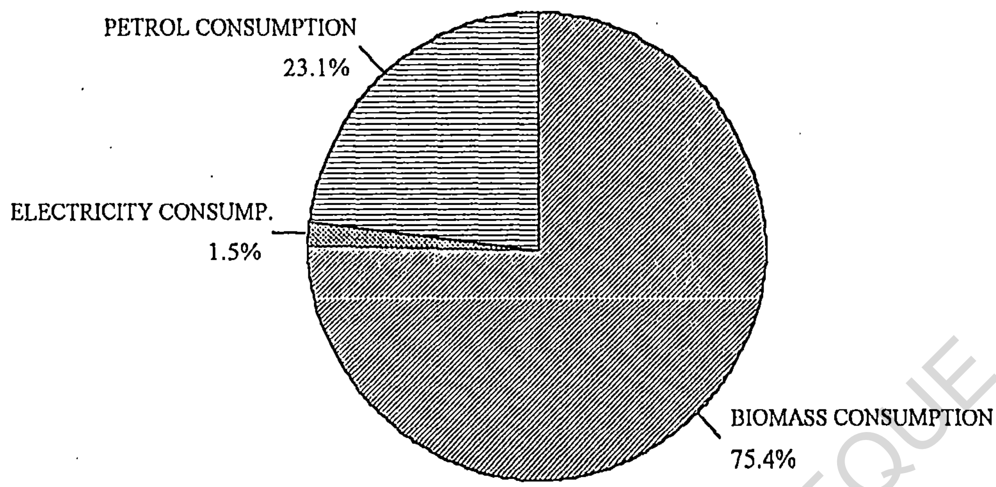
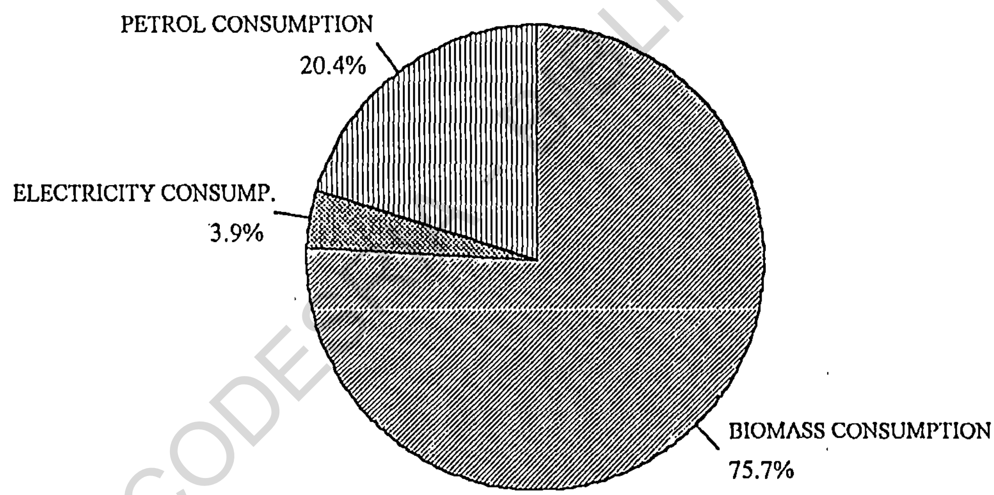
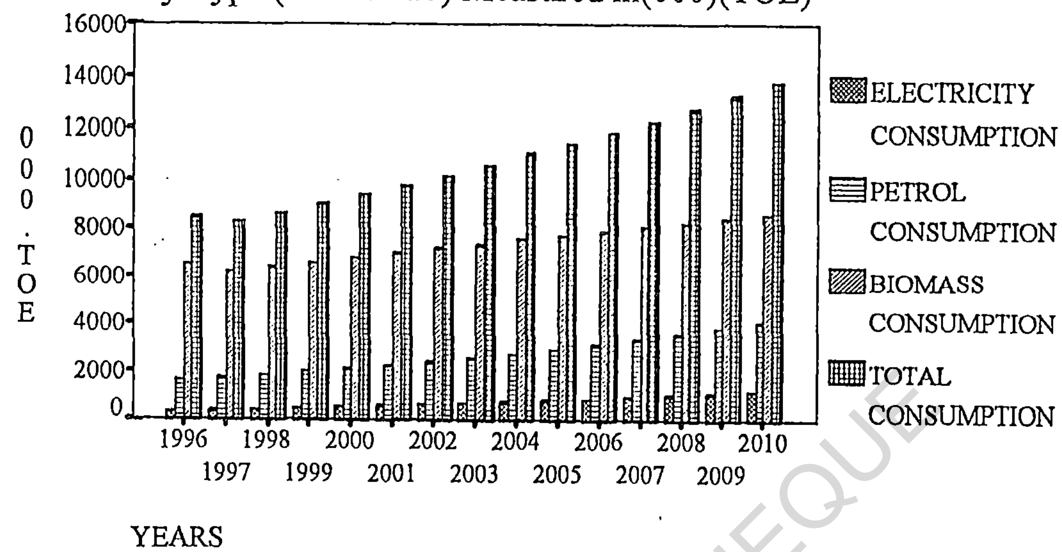


Figure (3.2.d)Average Energy Consumption By Type (1990-1996) Measured in(%)



Figure(3.3.a)Forecasts of Total Energy Consumption By Type (1996-2010) Measured in(000)(TOE)



Figure(3.3.b)Forecasts Of Average Total Energy Consumption by Type (1996-2010) Measured in(%)

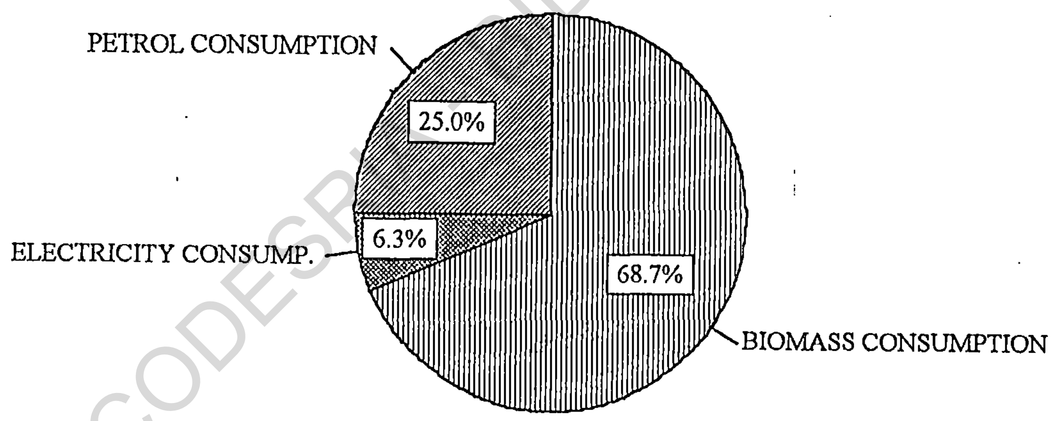


Figure (3.4.a)Total Energy Supply and Demand
(1987-1993) Measured in Million(TOE)

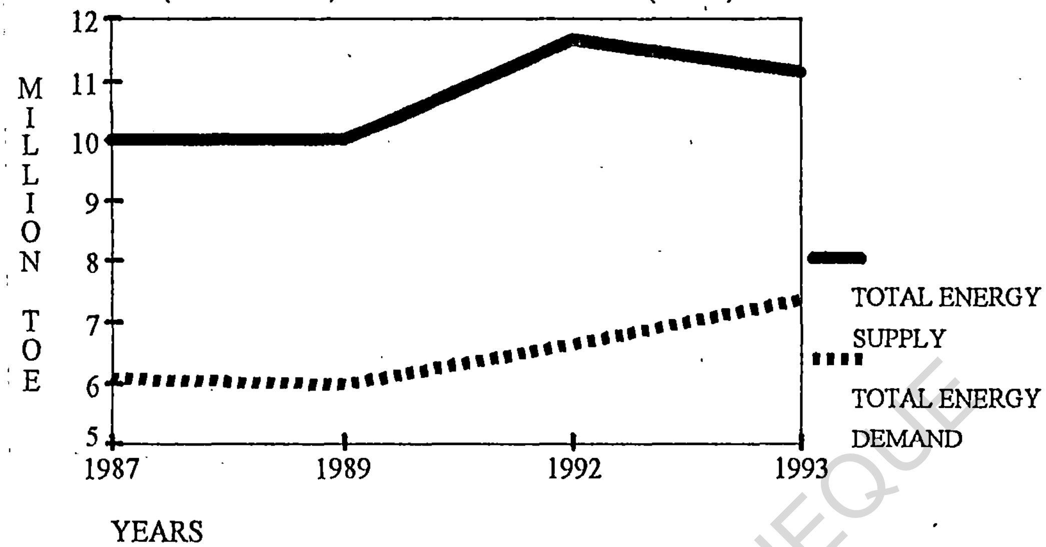
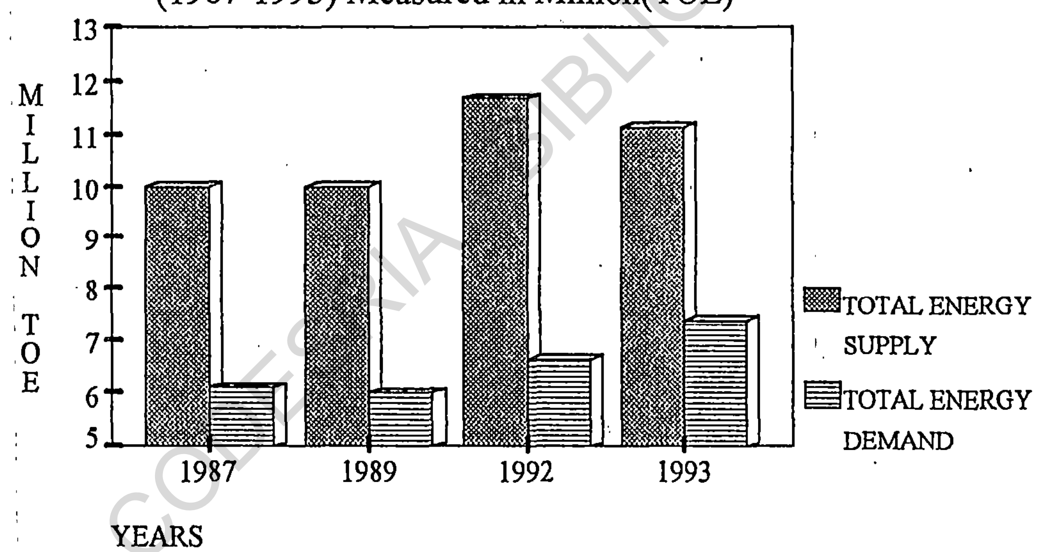
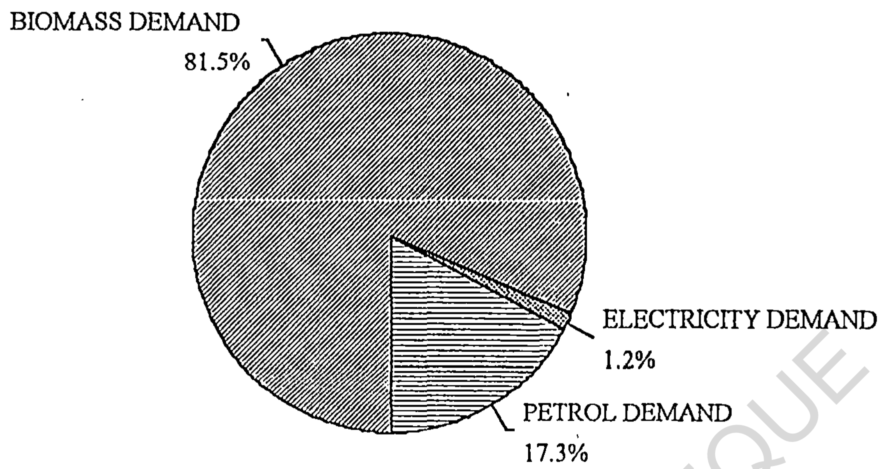


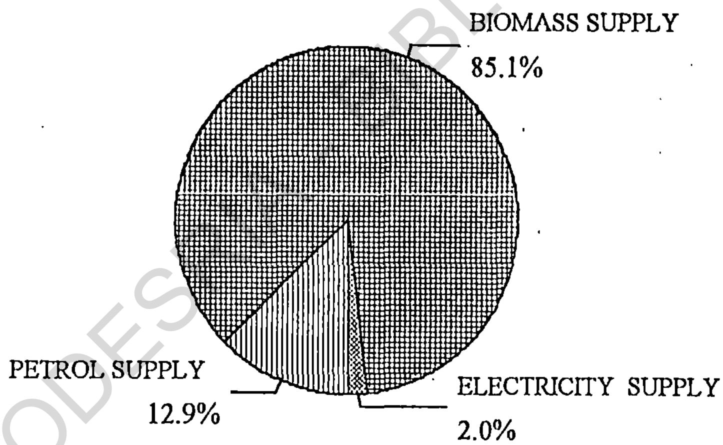
Figure (3.4.b)Total Energy Supply and Demand
(1987-1993) Measured in Million(TOE)



Figure(3.4.c)Energy Demand By Type
(1983-1993) Measured in(%)



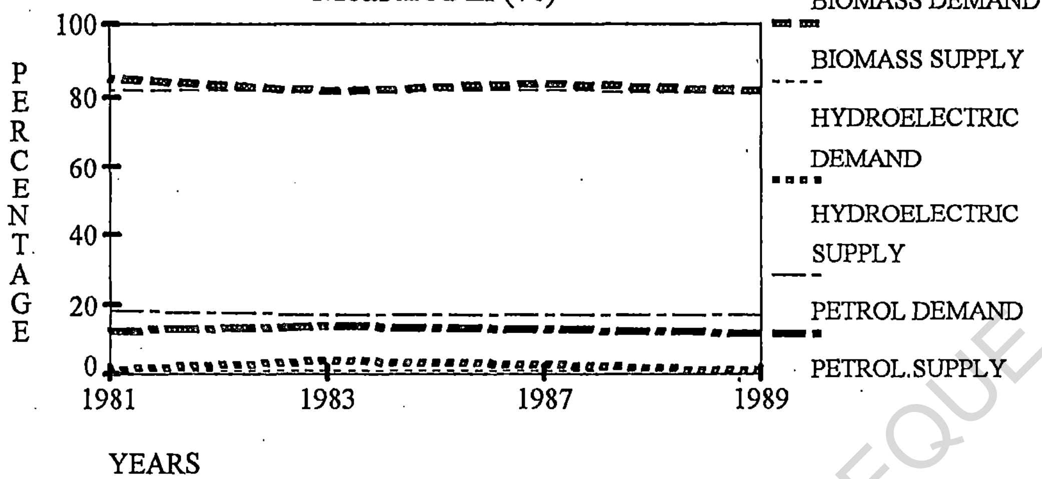
Figure(3.4.d)Energy Supply By Type
(1983-1993) Measured in(%)



Figure(3.4.e)Total Energy Supply And Demand

By Type (1981-1989)

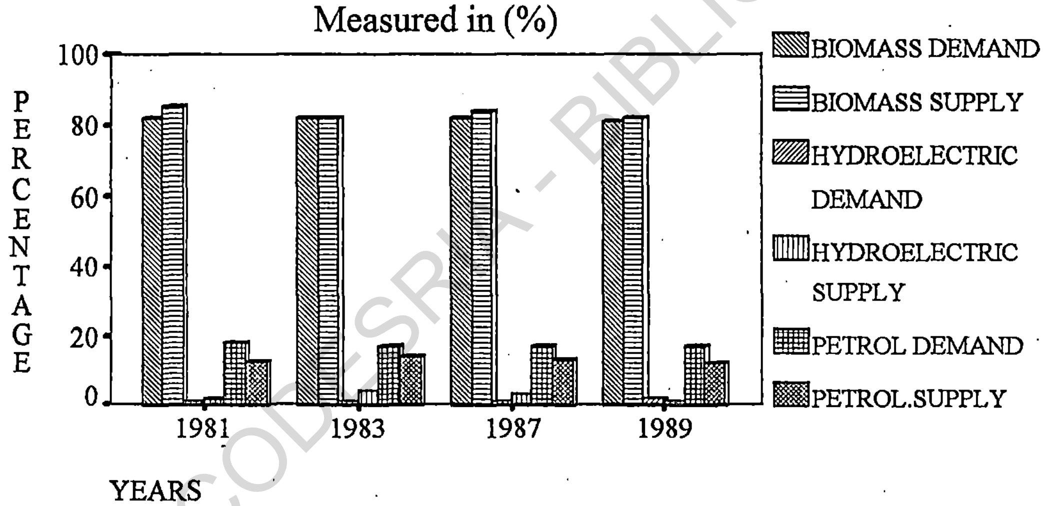
Measured in (%)



Figure(3.4.f)Total Energy Supply And Demand

By Type (1981-1989)

Measured in (%)



Figure(3.5.a)Electicity Total Sectoral Consumption (1985-1994) Measured in (GWH)

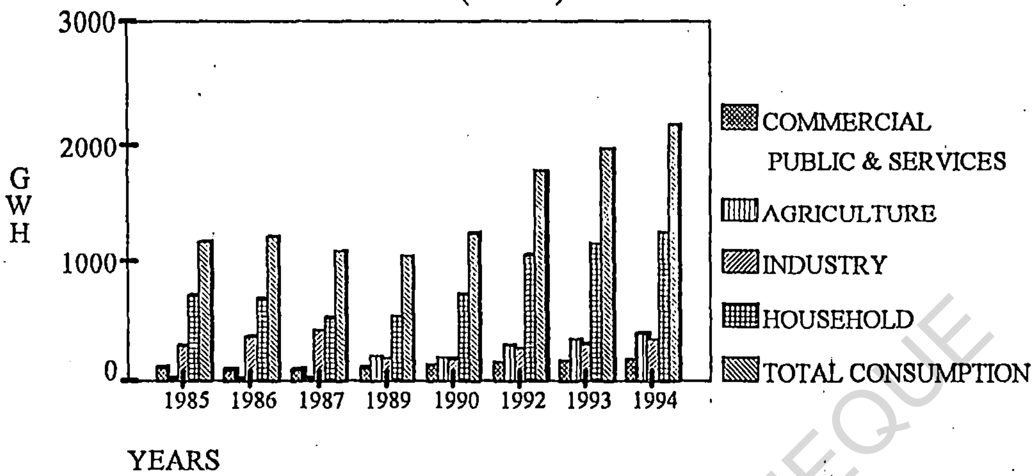
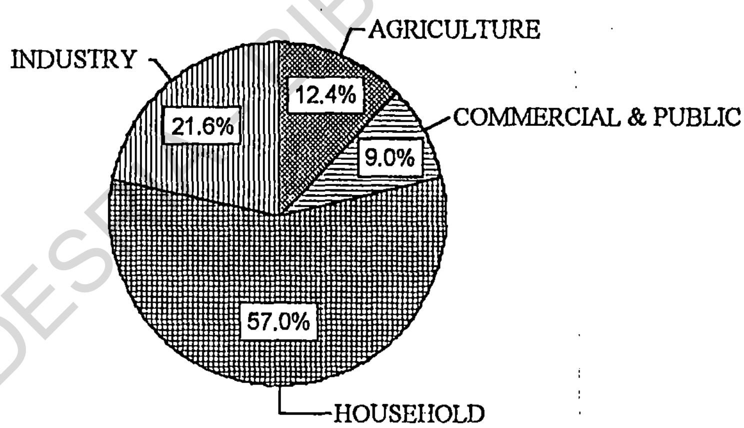


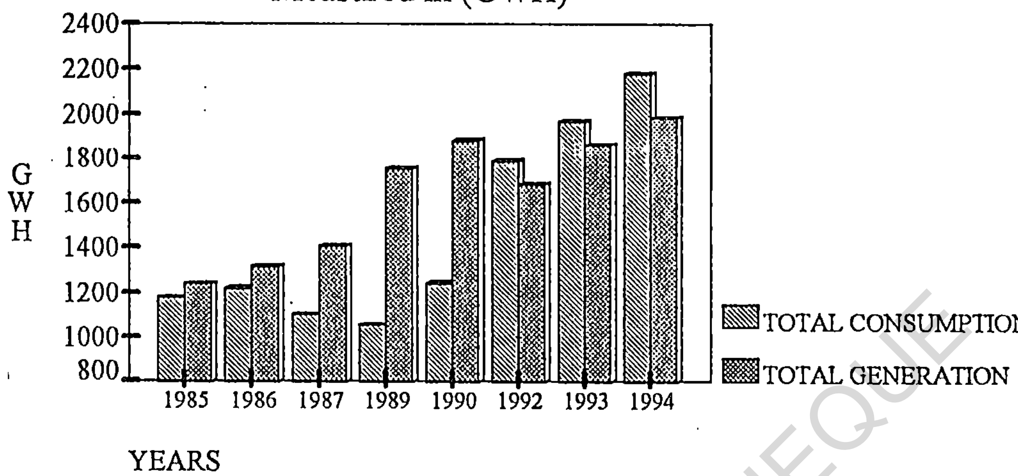
Figure (3.5.b)Electricity Average Sectoral Consumption (1985-1994)

Measured in (%)



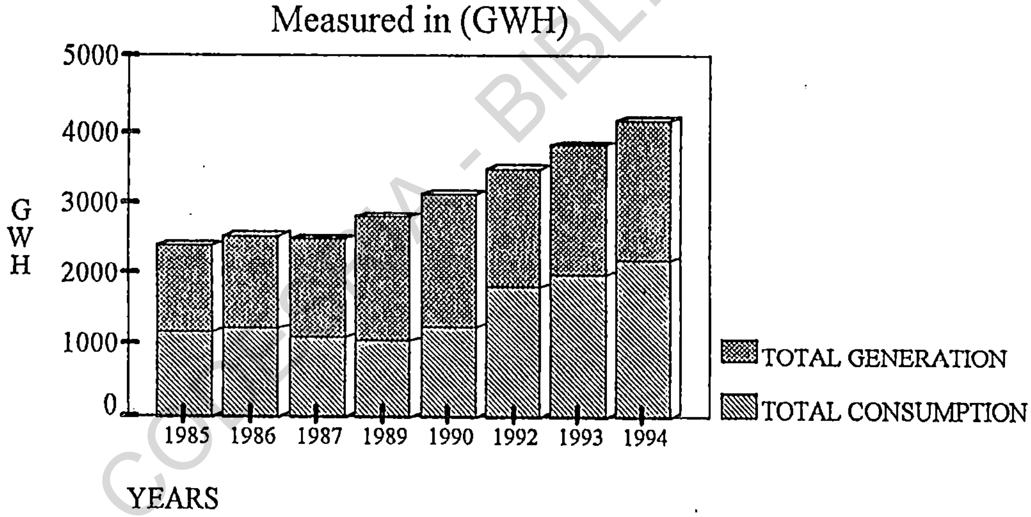
Figure(3.5.C) Total Elecricity Consumption and Generation (1985-1994)

Measured in (GWH)



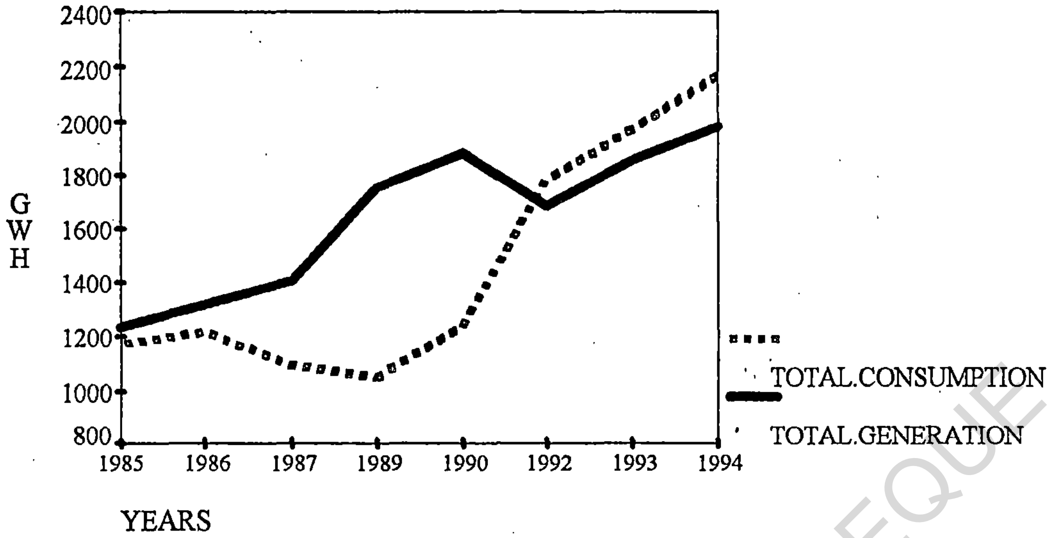
Figure(3.5.d) Total Elecricity Consumption and Generation (1985-1994)

Measured in (GWH)



Figure(3.5.e) Total Elecricity Consumption and Generation

(1985-1994) Measured in(GWH)



Figure(3.5.f) Electricity Consumption Sectoral

Growth Rate (1993/94-1994/95)

Measured in (%)

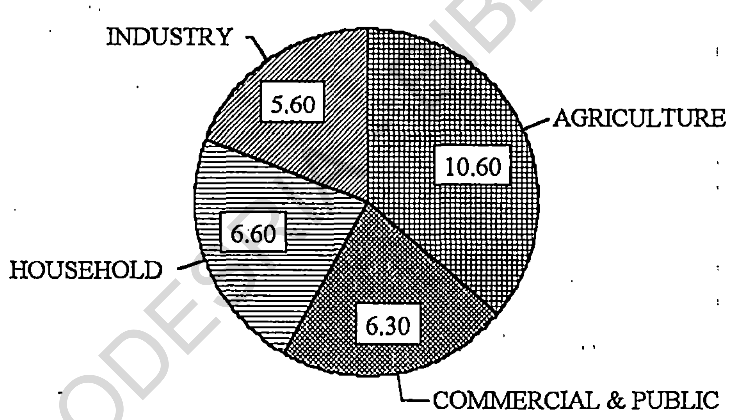


Figure (3.6.a) Energy Expenditures and Total Development Expenditures (1981-1994) Measured in Million (LS)

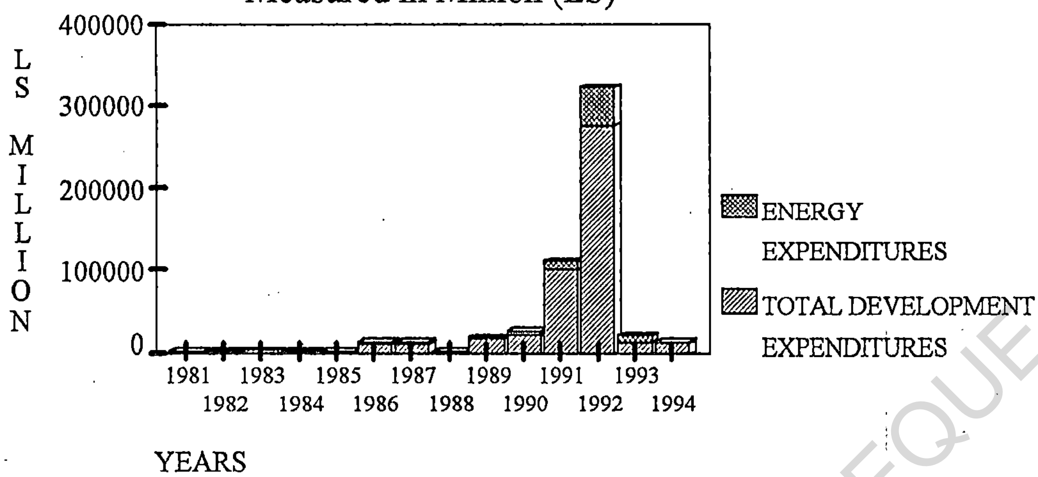
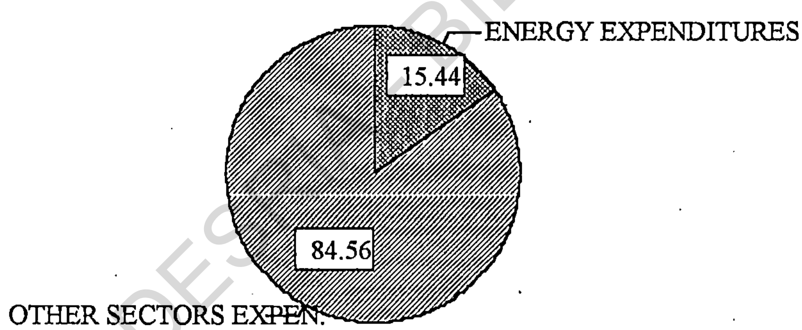


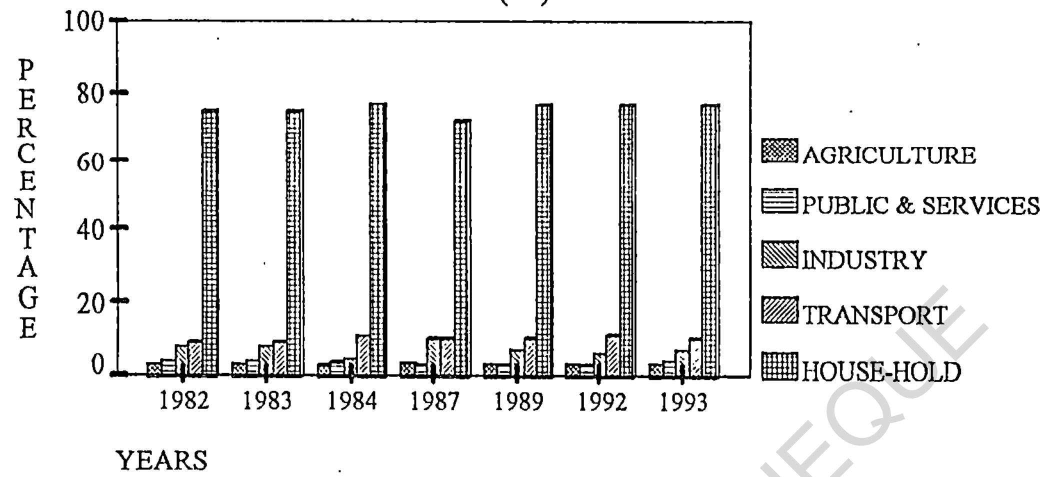
Figure (3.6.b) Average Energy Expenditures and Other Sectors Expenditures (1981-1994) Measured in (%)



Figure(3.7.a)Total Sectoral Energy Consumption

By Type (1982-1993)

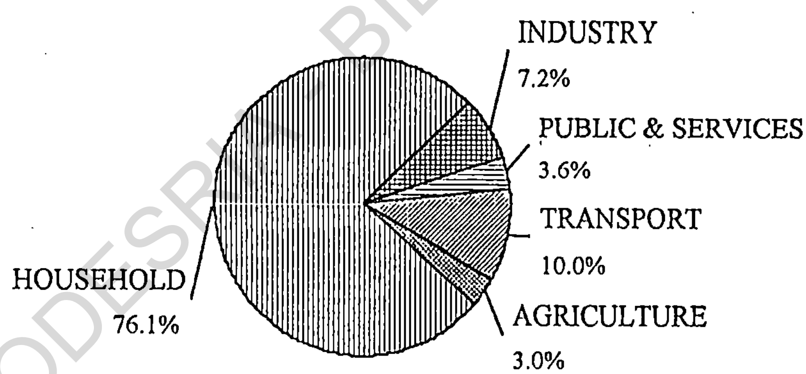
Measured in(%)



Figure(3.7.b) Average Total Sectroal Energy

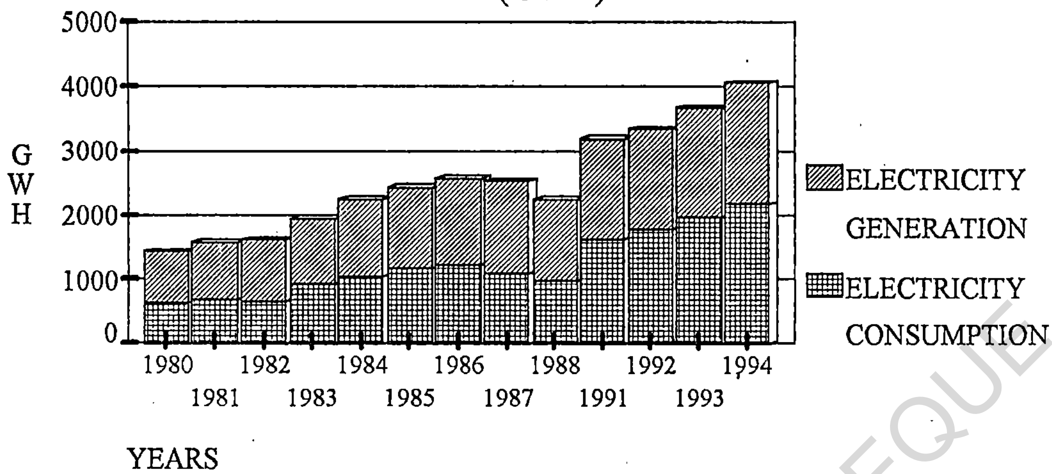
Consumption(1980-1993)

Measured in(%)



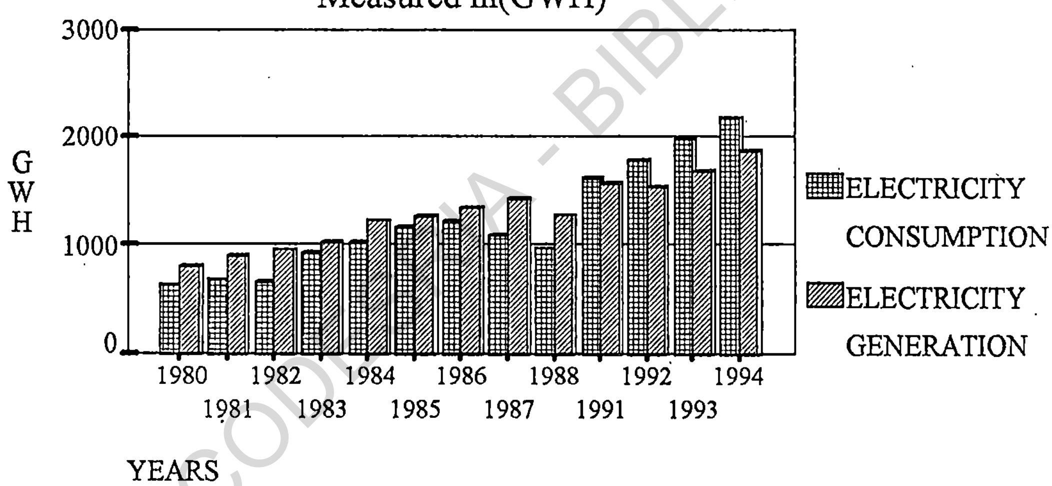
Figure(3.8.a)Total Electricity Consumption and Generation (1980-1994)

Measured in(GWH)

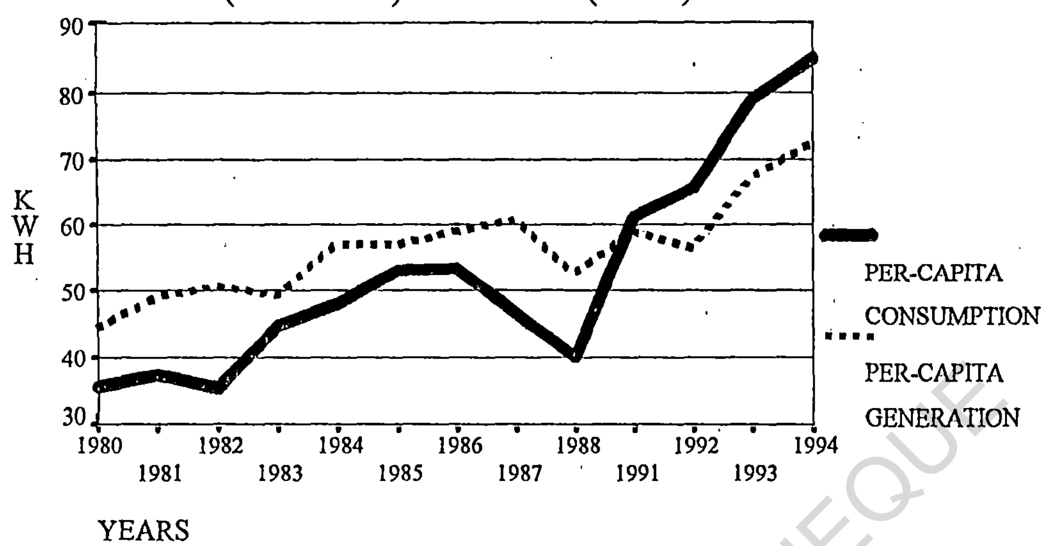


Figure(3.8.b)Total Electricity Consumption and Generation (1980-1994)

Measured in(GWH)

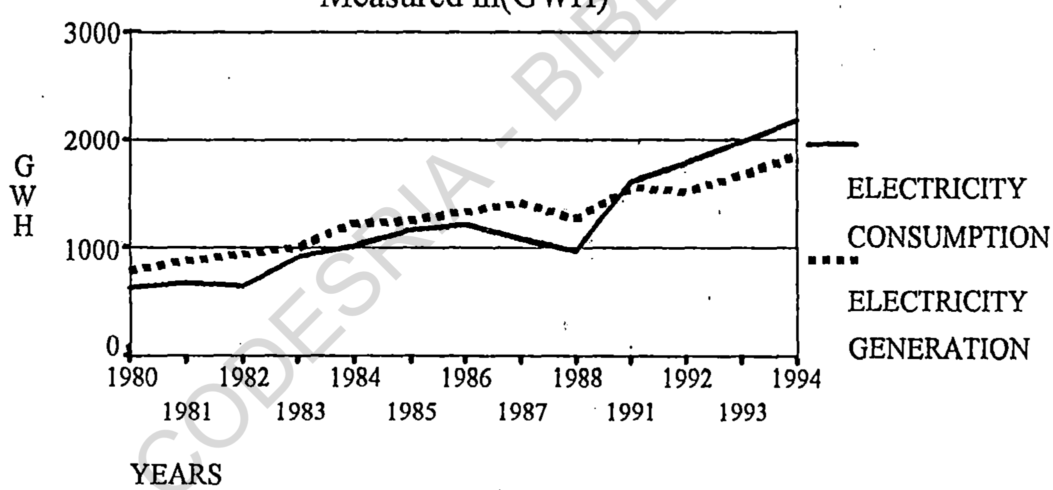


Figure(3.8.c)Per-capita Electricity Consumption and Generation (1980-1994)Measured in (KWH)

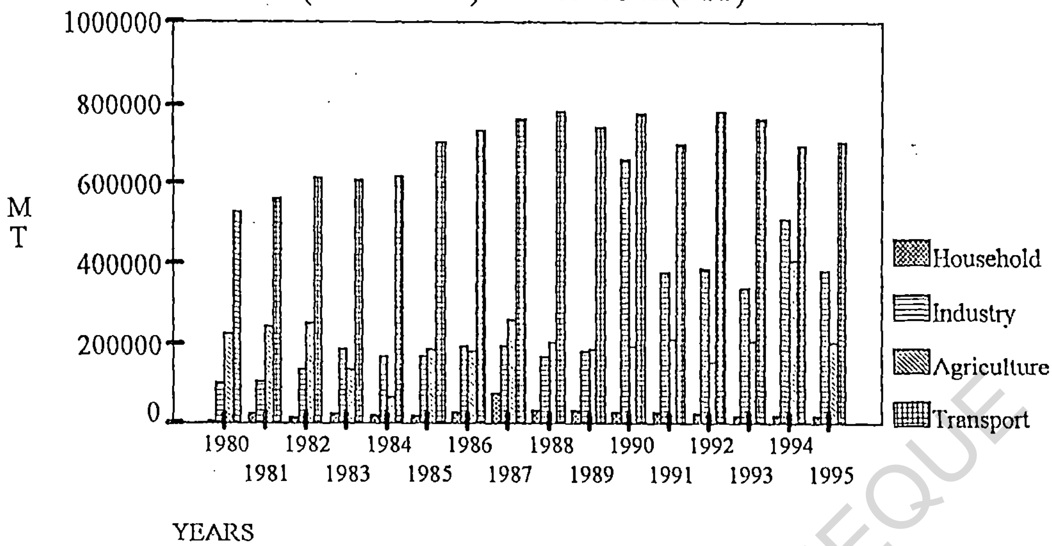


Figure(3.8.d)Total Electricity Consumption and Generation (1980-1994)

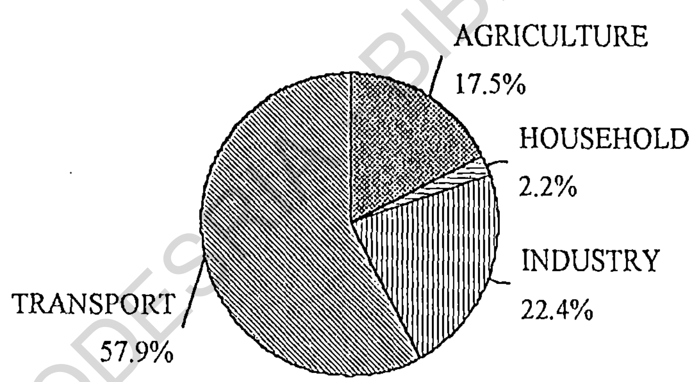
Measured in(GWH)



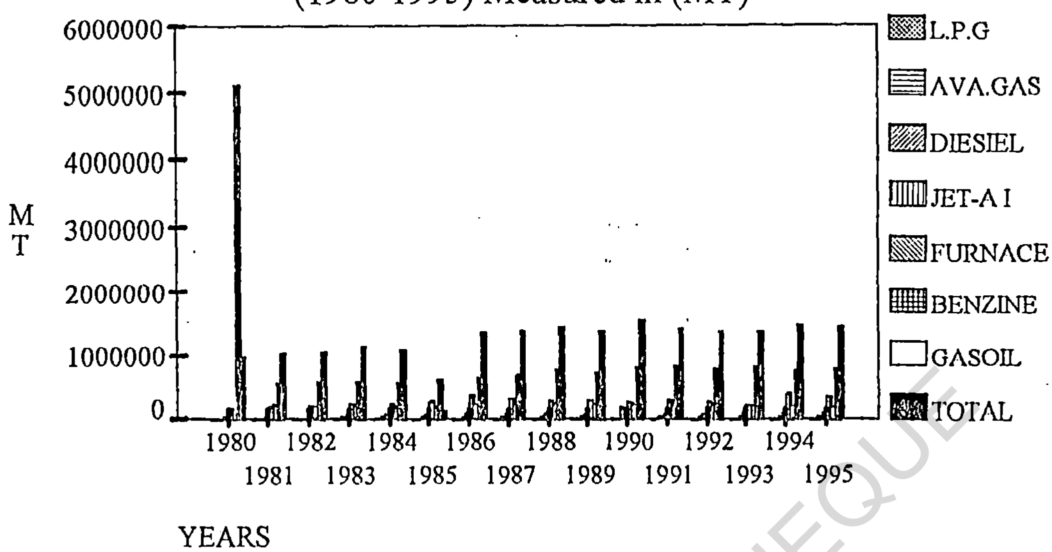
Figure(5.1.a)Petrol Total Sectoral Consumption (1980-1995) Measured in(MT)



Figure(5.1.b)Petrol Average Sectoral Consumption(1980-1995) Measured in(%)



Figure(5 .2.a) Petroleum Products Consumption (1980-1995) Measured in (MT)



Figure(5.2.b)Petroleum Products Consumption(1980-1995) Measured in(%)

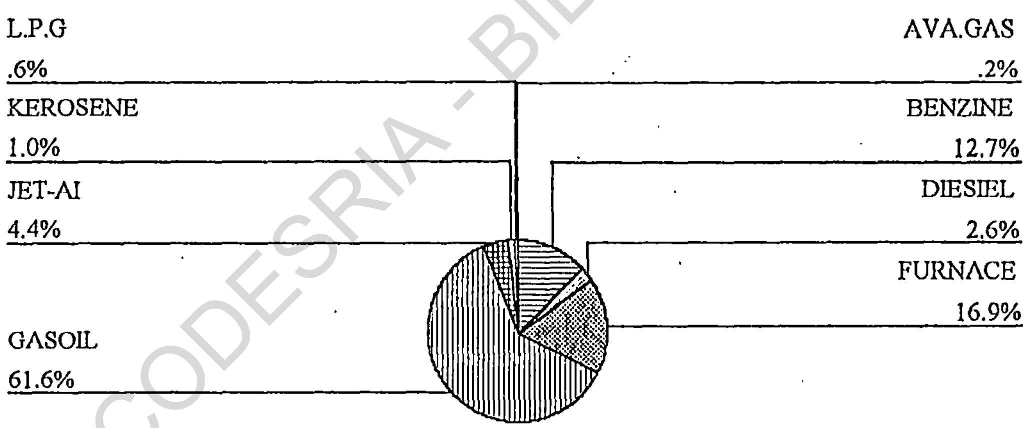
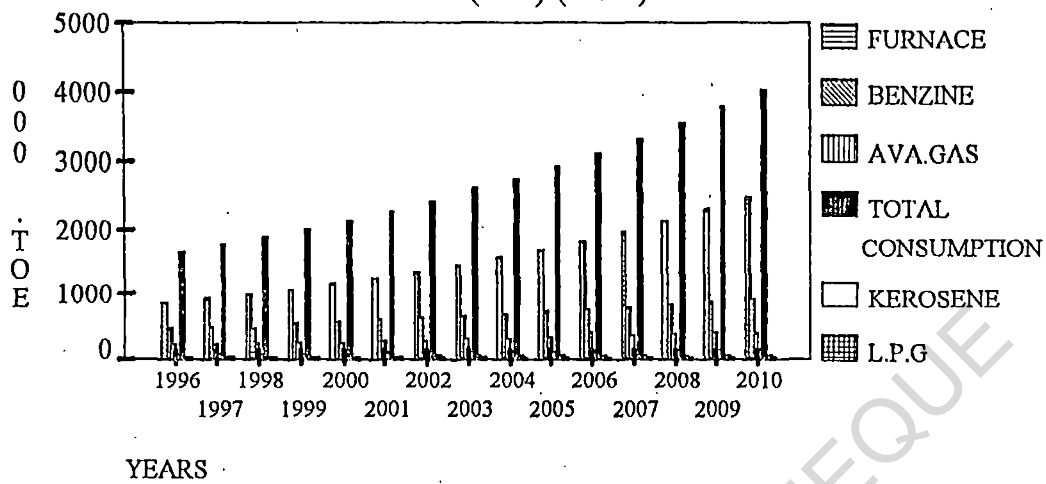
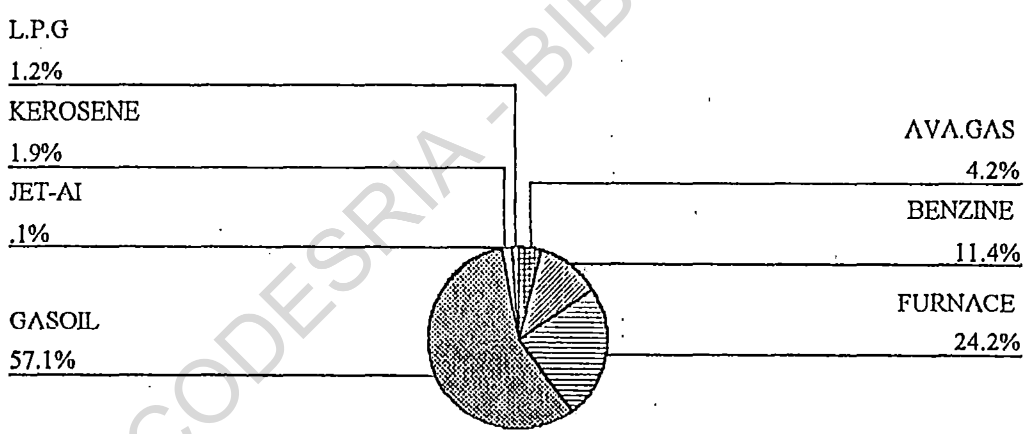


Figure (5.3.a) Forecasts of Petroleum Products Consumption (1996-2010) Measured in (000) (TOE)



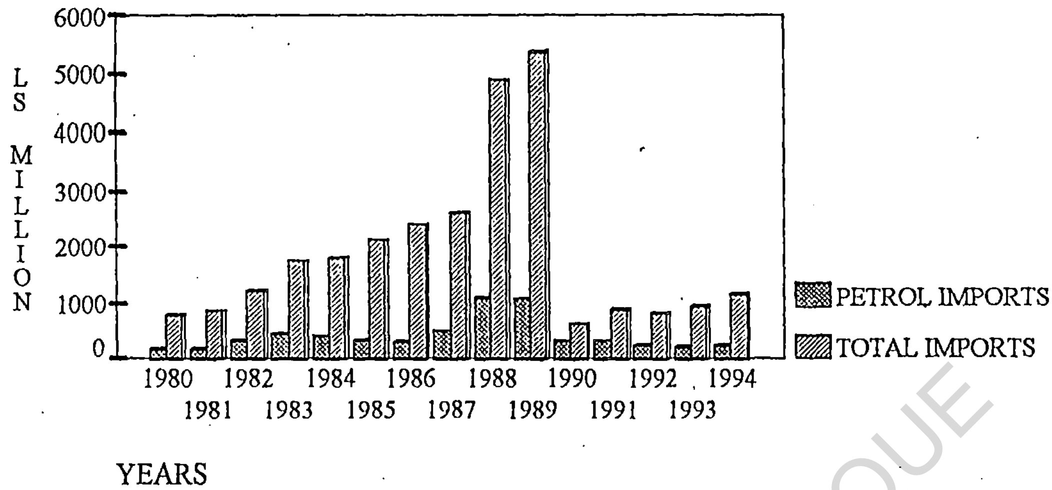
Figure(5.3.b)Forecasts of Average Petroleum Products Consumption (1996-2010)

Measured in(%)



Figure(5.4.a)Petrol Imports and Total Imports

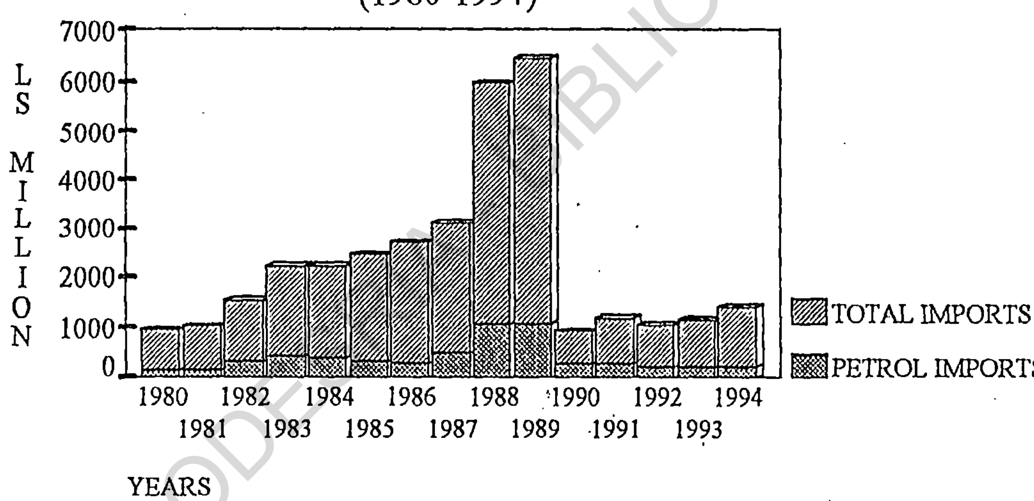
(1980-1994)



(1)*The years 1990,1991,1992,1993 and 1994 in Million dollar

Figure(5.4.b)Petrol Imports and Total Imports

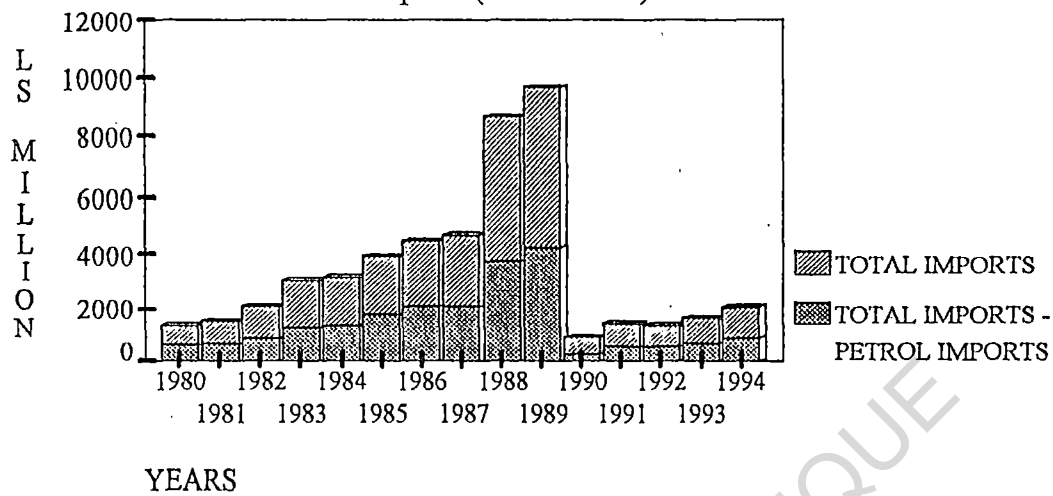
(1980-1994)



(1)*The years 1990,1991,1992,1993 and 1994 in Million dollar

Figure(5-4.c)Total Imports With and Without

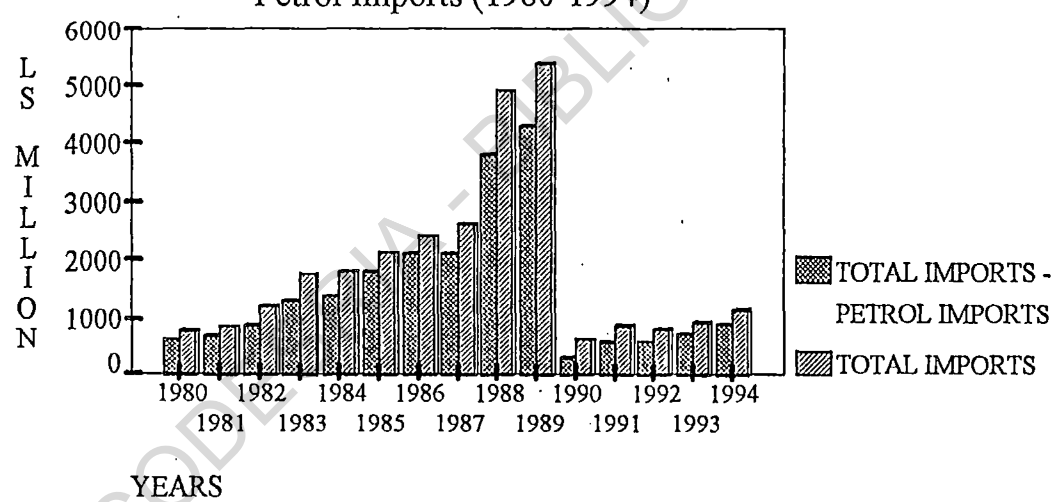
Petrol Imports(1980-1994)



(1)* The years1990,1991,1992,1993 and 1994 in Million dollar

Figure(5-4.d)Total Imports With and Without

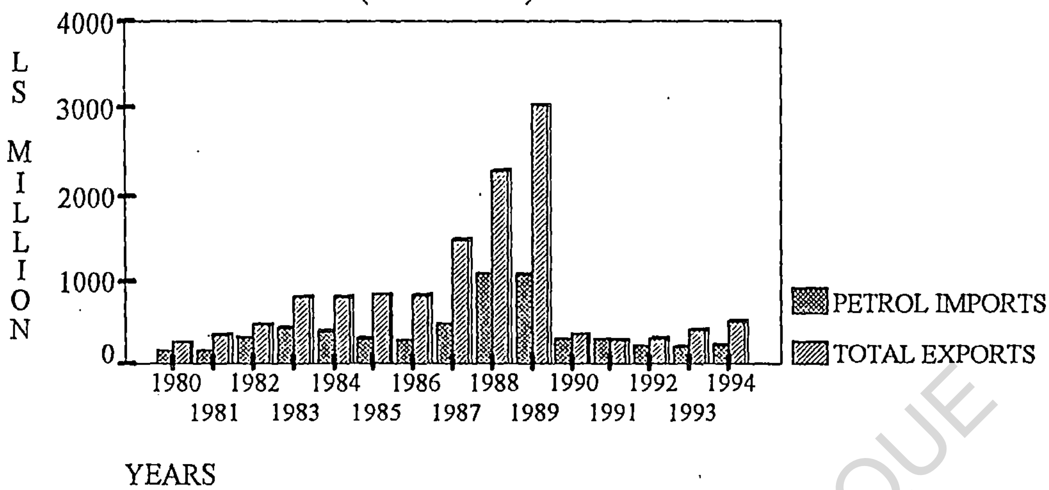
Petrol Imports (1980-1994)



(1)* The years1990,1991,1992,1993 and 1994 in Million dollar

Figure(5-5.a)Petrol Imports and Total Exports

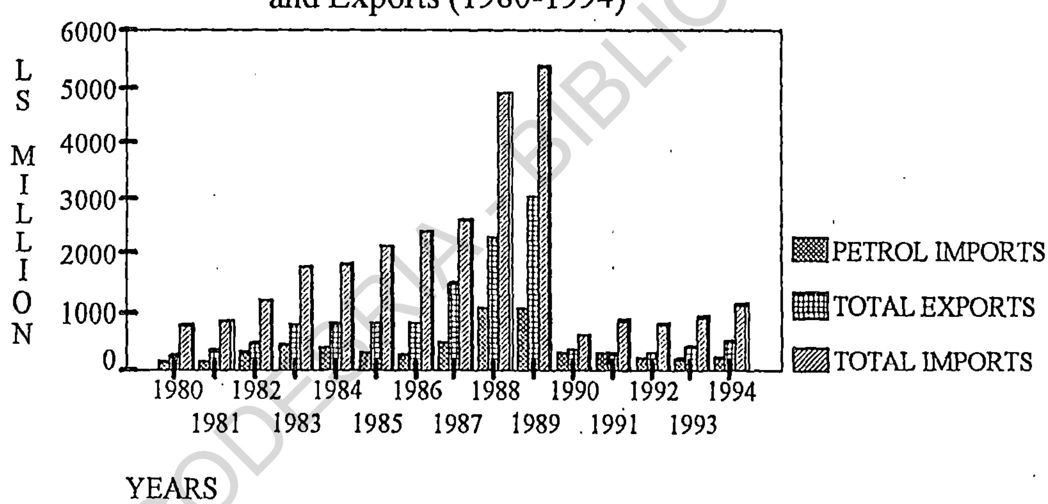
(1980-1994)



(1)* The years 1990,1991,1992,1993 and 1994 in Million dollar

Figure(5.5.b)Petrol Imports and Total Imports

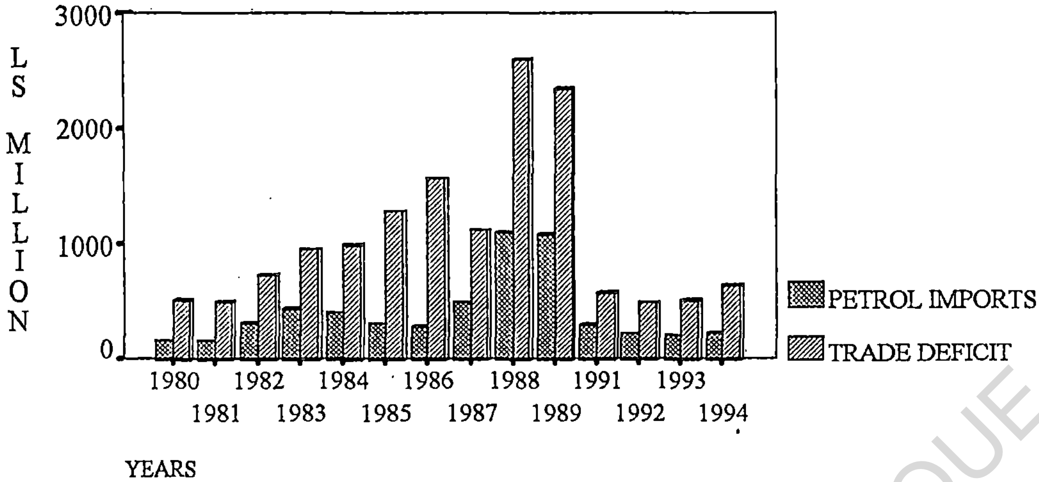
and Exports (1980-1994)



(1)* The years 1990,1991,1992,1993 and 1994 in Million dollar

Figure(5.6.a)Petrol Imports and Trade Deficit

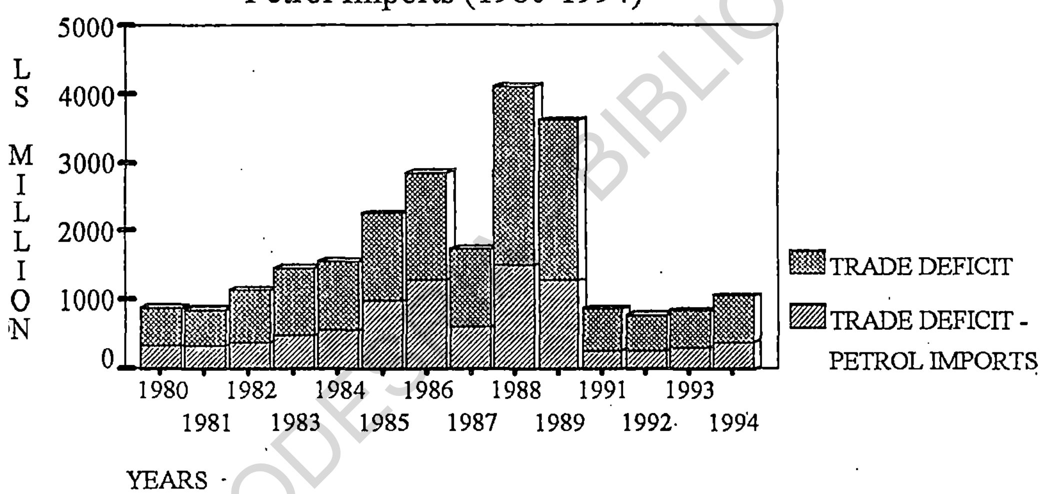
(1980-1994)



(1)* The years 1990,1991,1992,1993 and 1994 in Million dollar

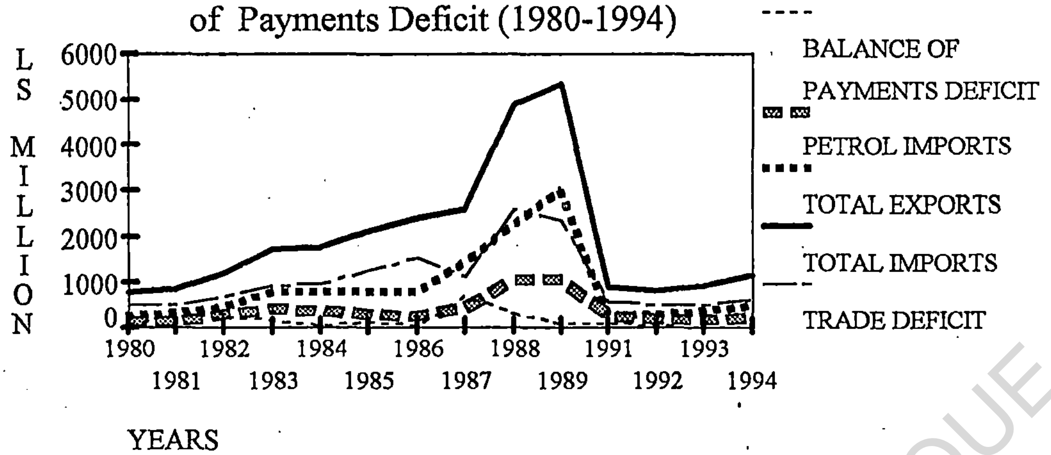
Figure(5.6.b)Trade Deficit With and Without

Petrol Imports (1980-1994)



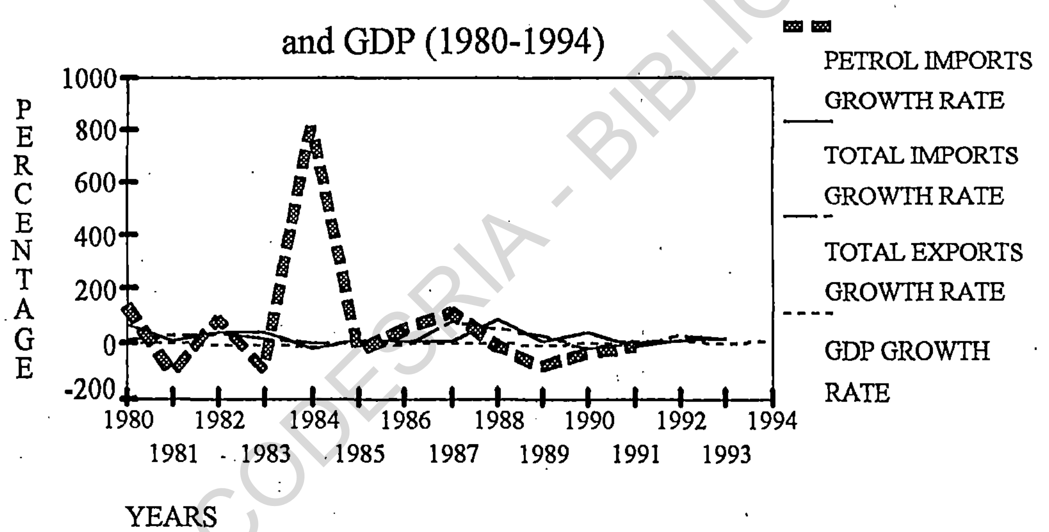
(1)* The years 1990,1991,1992,1993 and 1994 in Million dollar

Figure (5.6.c) Petrol Imports Total Imports and Exports, Trade Deficit and Balance of Payments Deficit (1980-1994)

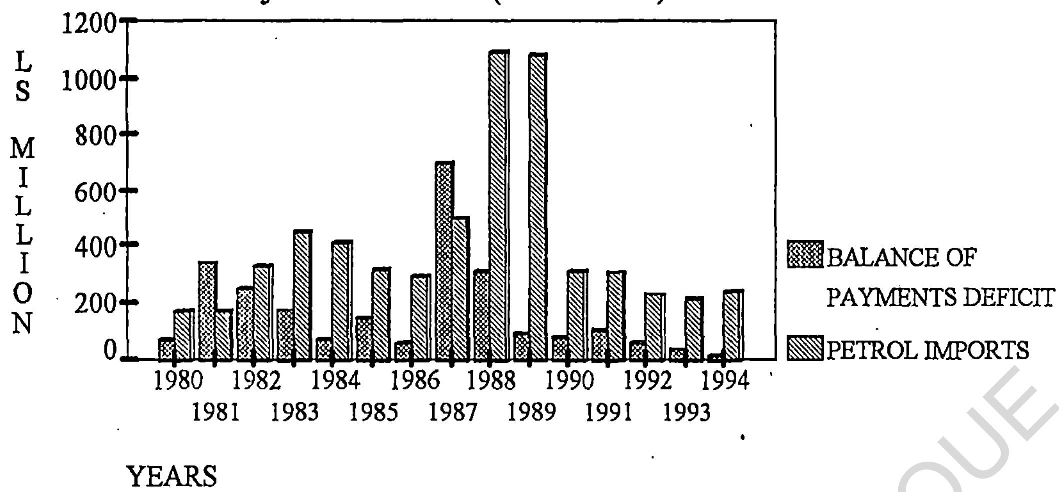


(1)*The years 1991,1992,1993 and 1994 in Million dollar

Figure (5.6.d) Growth Rate In Petrol Imports , Total Imports Total Exports, and GDP (1980-1994)

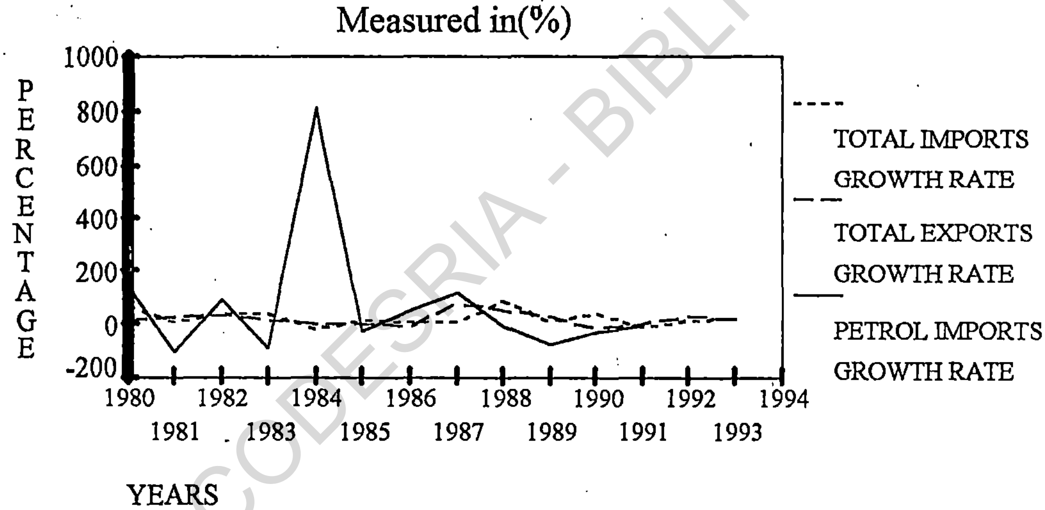


Figure(5.7.a)Petrol Imports and Balance Of Payments Deficits(1980-1994)



(1)* The years 1990,1991,1992,1993 and 1994 in Million dollar

Figure(5.7.b)Total Imports, Exports and Petrol Imports Growth Rate (1980-1994) Measured in(%)



Figure(5.8.a)Petrol and Foreign Energy Expenditures and Total Foreign Expenditures Measured in(LS) Million (1989-1993)

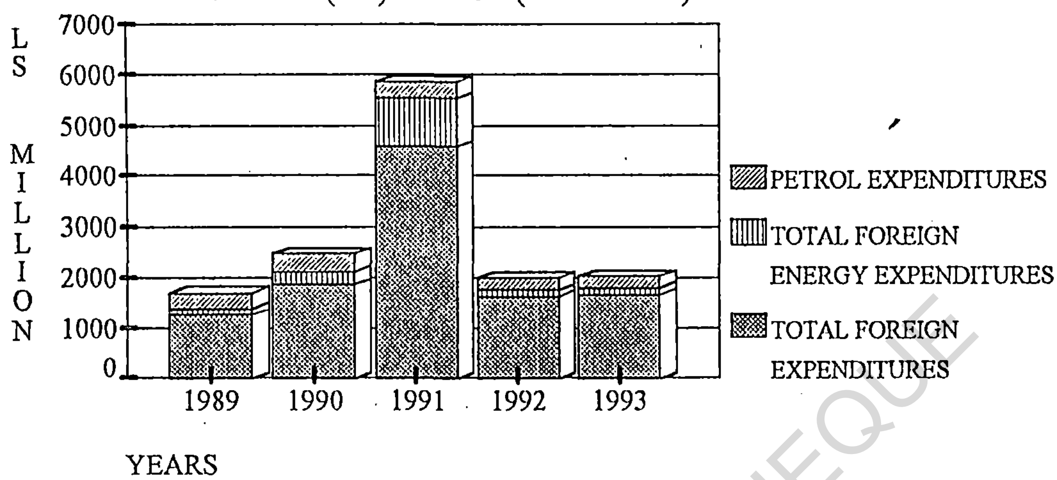
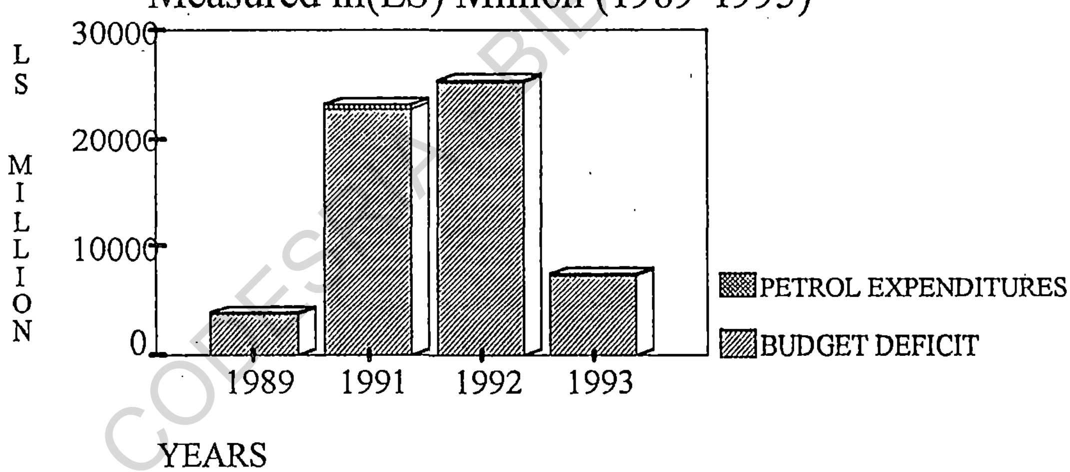
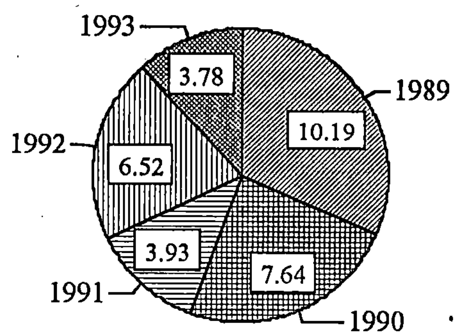


Figure (5.8.b) Petrol Imports Expenditures and Balance Budget Deficit Measured in(LS) Million (1989-1993)



Figure(5.8.c)Petrol Expenditures and Total Devlopment Expenditures (1989-1993) Measured in(%)



Figure(5.8.d)Total Energy Expenditures and Total Development Expenditures (1989-1993) Measured in(%)

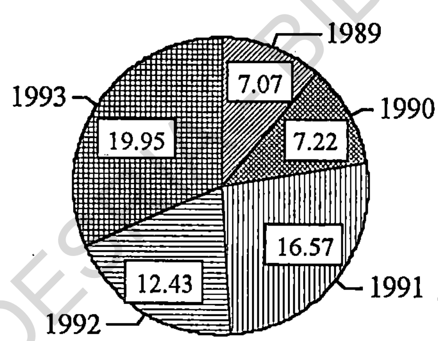
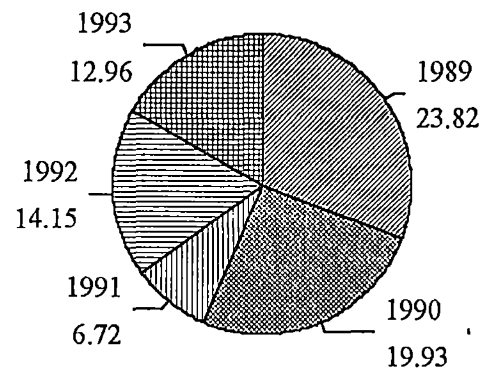
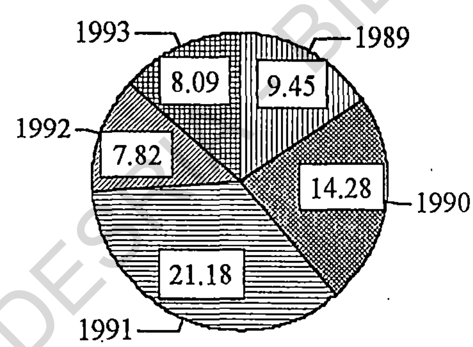


Figure (5.8.e) Petrol Expenditures and Total Foreign Development Expenditures (1989-1993) Measured in(%)



Figure(5.8.f) Energy Foreign Expenditures and Total Foreign Development Expenditures (1989-1993) Measured in (%)



Figure(5.9)Petrol Imports And (GDP) Growth Rate (1980-1992) Measured in(%)

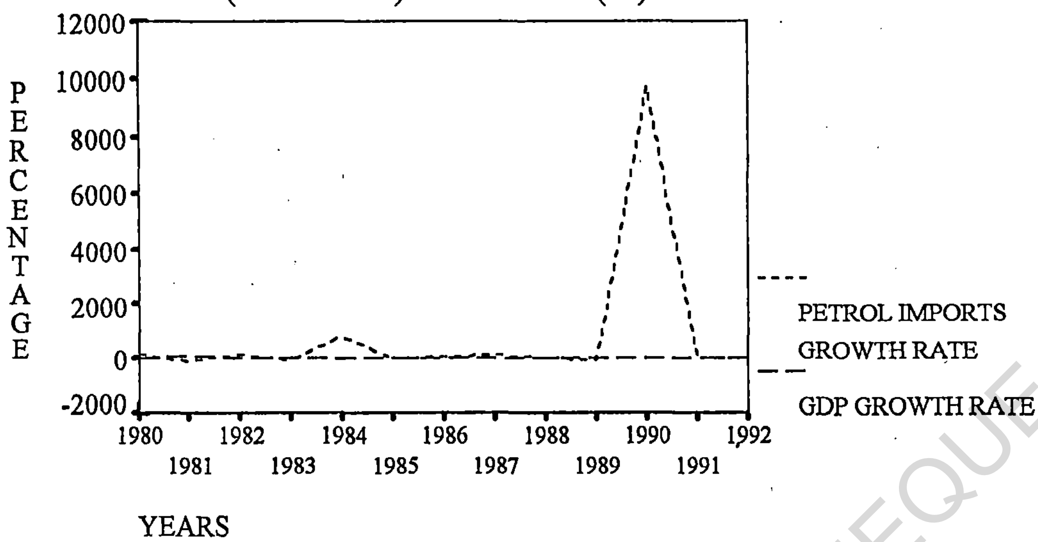


Figure (5.10) Petrol Imports Growth Rate and Inflation (CPI-Growth Rate) Measured in(%) (1980-1991)

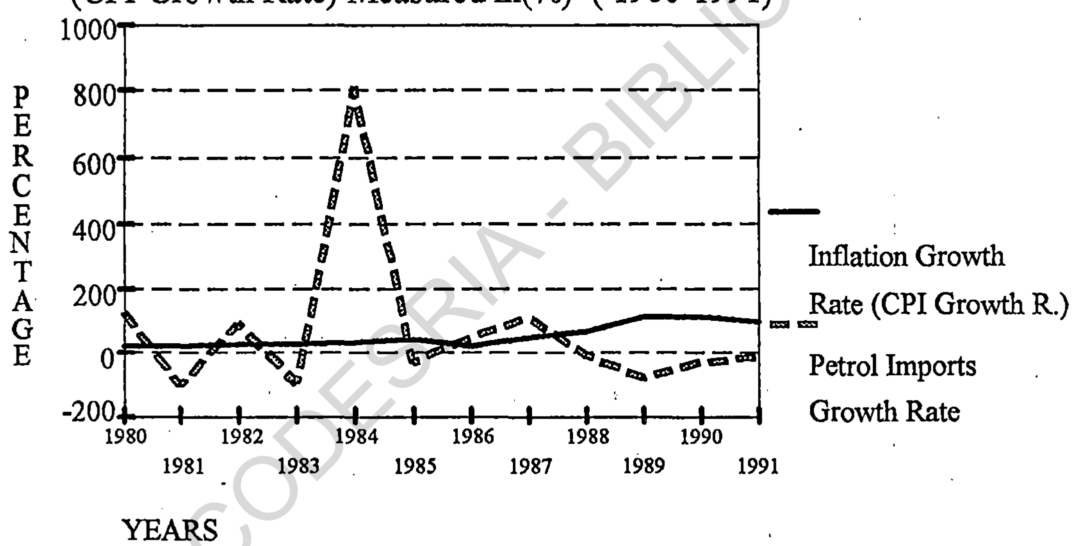


Figure (5.11.a)The Rate of Energy Consumption

By Type To Total Energy

(1980-1989) Measured in (%)

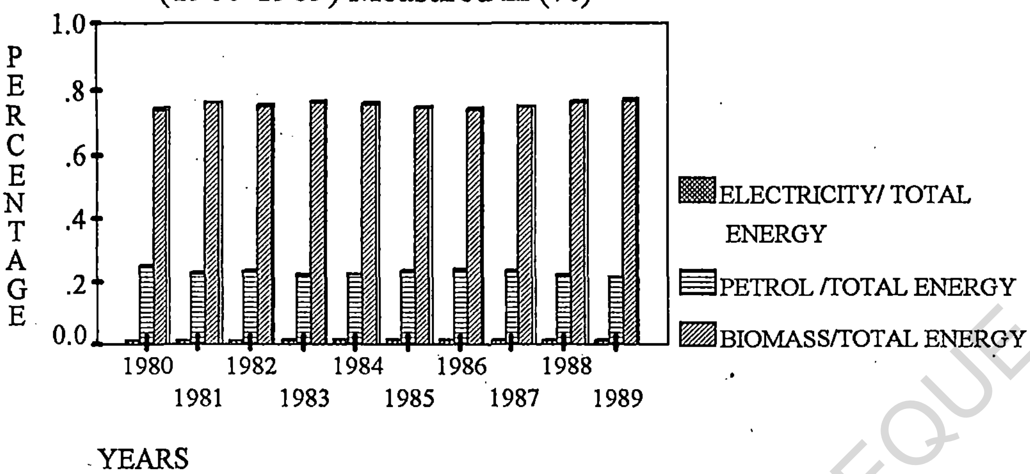


Figure (5.11.b) Growth Rate in Total Energy Type

GDP and Inflation

(1981-1989) Measured in(%)

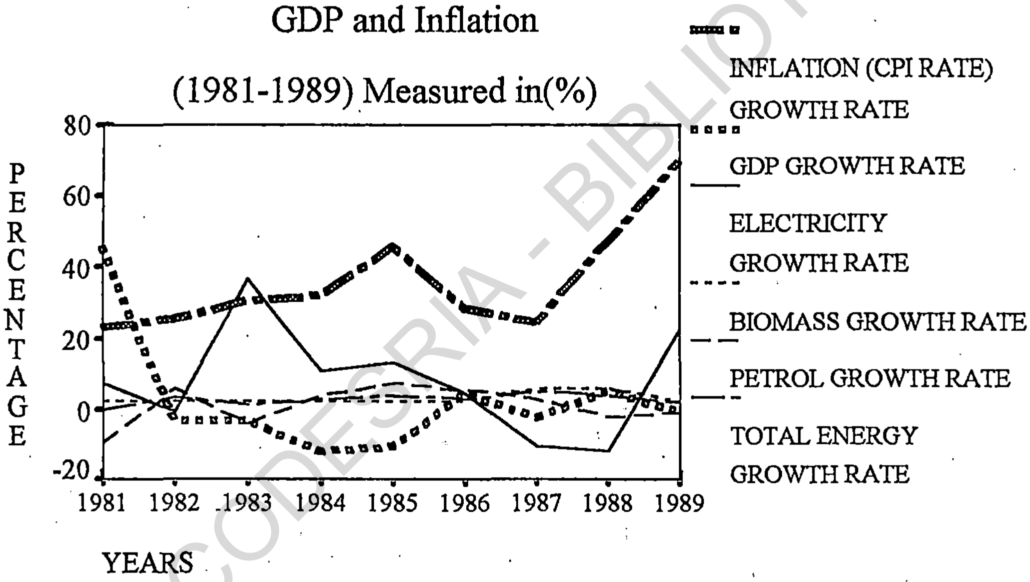
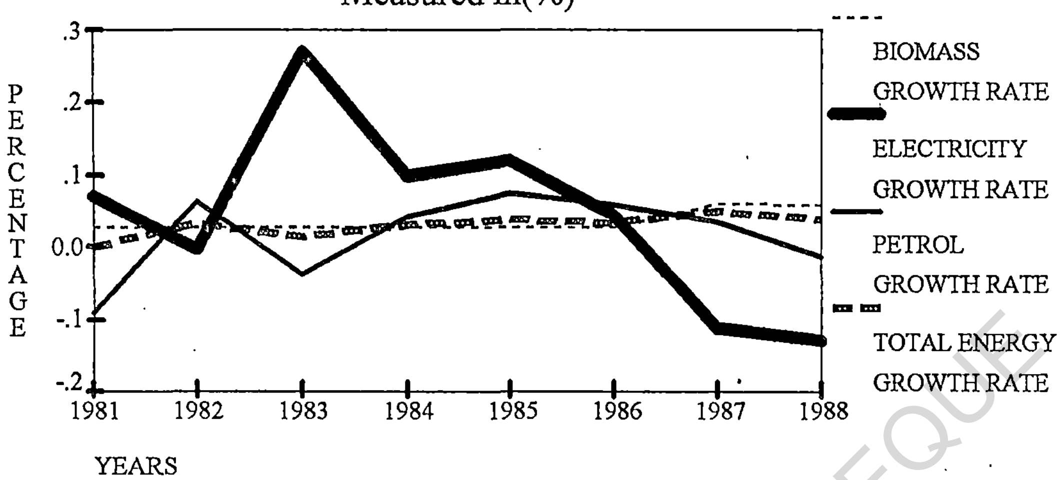


Figure (5.11.c) Growth Rate in Total Energy Consumption

By Type (1981-1988)

Measured in(%)



Figure(5.11.d) Average Growth Rate in Energy

Consumption By Type (1981-1989)

Measured in(%)