COMMERCIAL ENERGY CONSUMPTION AND ECONOMIC DEVELOPMENT

A LOOK INTO ETHIOPIA'S ENERGY PROBLEM

By

AHMED MOHAMMED

ADDIS ABABA UNIVERSITY
COLLEGE OF SOCIAL SCIENCES
DEPARTMENT OF ECONOMICS
JUNE 1982

COMMERCIAL ENERGY CONSUMPTION AND ECONOMIC DEVELOPMENT: A LOOK INTO ETHIOPIA'S ENERGY PROBLEM.

A Thesis
Presented to the
School of Graduate Studies
Addis Ababa University

In Partial Fulfillment
of The Requirements for The Degree
Master of Science in Economics

By
Ahmed Mohammed
June 1982

ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

COMMERCIAL ENERGY CONSUMPTION AND ECONOMIC DEVELOPMENT

A LOOK INTO ETHIOPIA'S ENERGY PROBLEM

by

Ahmed Mohammed

College of Social Sciences

Department of Economics

Approval by Board of Examiners

Tisseha Tegegne	[signature]
Chairman, Department Graduate Committee	
Shiferaw Gurmu	[signature]
Advisor	
Tisseha Tegegne	[signature]
Examiner	
FASSIL G. KIROS	Fassil
Examiner	
Assefa Teferri	[signature]
Examiner	

TABELE OF CONTENTS

ACKNOWLEDGEMENT

Quite a number of people have helped me at different stages of my work. Among many who have helped me and whom I ought to particularly mention are, Dr. Gebru Woldegiorgis, Excutive Secretary and Ato Lemma Eshetu of Ethiopian National Energy Committee, Ato Kebede Akalewold, General Manager of Ethiopian Petroleum Corporation, Ato Wondimu Bogale of EELPA and Ato Tadiwos H/Work of the Ministry of Industry for providing me with valuable information and data as well as sharing their experience with me.

I am also highly grateful to Dr. Fassil G. Kiros, Dr. Assefa Teferri, Ato Fisseha Tegegne and Ato Shifferaw Gurmu for their valuable advice and constructive suggestions in improving my work.

Special thanks are due, Ato Berhanu Alemayehu, Ato Yimer Kifle, Ato Bekele Asfaw, Ato Tesfaye Berhane, Ato Teferra Berhe, W/o Almaz Gedle, W/t Ejigayehu Bekele, Ato Dibekulu Misganaw, Ato Tassew Asres, Ato Getachew W.Sellassie and the staff of the Systems Design Department of A.A.U. for their assistance in their various capacities to make early realization possible.

I owe an immeasurable debt of gratitude to W/O Teobista Alemayehu, W/o Tenagne Mulugeta, W/t Zereadam Asegahegn, W/t Bethelhem Mulugeta, for their forbearance and diligence in typing many pages of an almost illegible manuscript.

I owe a lot to Dr. Befekadu Degefe and Ato Taye Mengistae whose inspiring ideas, profundity of knowledge and invariable support and encouragement helped me a lot to sustain the strain.

I am exceptionally grateful to my friend Ato Mekonnen Tesfa-hunegn who shared all the stress and strain and without whose unstinging and unfailing help, selfless and devoted collaboration timely accomplishment would have been enormously difficult, if not impossible.

LIST OF FIGURES

PAGE

T E X T   T A B L E S

PAGE

Pointers on Energy[1]

When people talk about energy, it is not always clear what kind of energy they are talking about and this adds to the problem. Therefore, in order to understand the physical energy system, it is important to distinguish between energy at various stages of conversion and use.

Primary energy is the energy recovered from natural-water flowing over a dam, coal freshly mined, oil, natural gas, natural uranium. Only rarely ca primary energy be used to supply final energy - energy used to supply the consumer with energy services. One of the few forms of primary energy that can be used as final energy is ntural gas, which is why it is a fuel of preference whenever it is available.

For the most part, primary energy is converted into secondary energy. This is defined as an energy form that can be used over a broad spectrum of applications. Electricity and gasoline are the major examples. Less convenient (which is why they are declining in their market shares) forms of secondary energy include charcoal, sorted and graded coal, and cut and split fuel-wood. In order to apply energy without making undue demands on the consumer, it must be converted into a form that may be readily transported, distributed and used in a variety of devices. The trend has been toward grids, for obvious reasons, specifically toward electricity, gas, and district heating grids. For convenience of storage, portability and transportability, the trend has also been to liquid fuels, of which gasoline and diesel oil are the best examples.

Primary energy is converted into secondary energy in several different ways. For example, central power plants produce electricity and, sometimes district heat. Refineries convert petroleum to more convenient liquid fuels - gasoline, jet fuel diesel oil, and naphtha. There are conversion losses in going form primary to secondary energy and transmission losses in getting that energy to the consumer.

These final steps are the conversion of secondary energy into final energy - the energy in a motor, a stove, a computer, or a light bulb - and of final energy into useful energy - the energy actually stored in a product or used for a service. It is important to realize that in providing the service - say, a well-lit room-energy is not merely a stored entity, but even more an input for the efficient use of other resources, of labor, of capital, and especially of skill.

The collective terms used to describe various energy groups are poorly defined, and several meanings for similar terms can be found in the literature on the subject. Collective terms used in this paper are defined as follows:[2]

Conventional Energy: Energy sources which have hitherto provided the bulk of the requirements for modern industrial society, i.e. coal (including lignite and peat); petrolium (including fuel oil, gasoline, kerosene, diesel fuel, natural gas and liquefied petroleum gas); and electricity generated by burning one or other of these fuels, or from hydro or nuclear power. Wood is not included in this category although it was extensively used in the past, and still is to some extent, for industrial purposes!

Commercial Energy: Any energy form sold in the course of commerce or provided by a public utility. The term is virtually synonymous with conventional energy. Wood and other traditional fuels (see below) are not included although they are widely traded.

Renewable Energy: An energy form, the supply of which is partly or wholly regenerated in the course of the annual solar cycle. Thus solar and wind energy, hydropower, and fuels of vegetable origin are regarded as renewable; mineral fuels and nuclear power are not.

Biomass Fuels: Combustible and or fermentable material of vegetable origin, for example wood, charcoal, corn cobs, cotton stalks, rice husks, dung cakes.

Traditional Energy: Those energy forms generally used in "traditional" or pre-industrial societies. They are largely synonymous with biomass fuels and the term is generally regarded as including mineral fuels and hydropower, despite the fact that water wheels have been in use for over 1,000 years.

Solar Energy: Technologies that use solar radiation to provide heat, which can be converted to mechanical or electrical power, or to directly generate electricity (i.e. photovoltaic cells).

Photovoltaic Cells: Solid state devices which usually employ silicon cells to convert solar energy directly into electricity.

Anaerobic Processes: Biological/chemical processes taking place in the absence of oxygen.

Biogas: A fuel gas of "medium" value, generally containing 55 percent to 65 percent methane, generated from the anaerobic decomposition of organic materials.

Gasohol: A blend of gasoline and alcohol containing up to 20% of alcohol.

Small Hydro: While there is no generally accepted definition of "small," the concept as used in the paper refers to hydroelectric units with capacities not exceeding several hundred kilowatt and usually in the 5-50kw range. Units of this size are frequently referred to as "mini" or "micro" hydro. They are usually located at low-head sites and serve individual consumers or villages.

Liquified Petroleum Gas (LPG): Propane and butane gas liquified, at ambient tempratures by pressure, or refrigerated to -45°c (-50°F) at atmospheric pressure.

Natural Gas: Any hydrocarbon or mixture of hydrocarbons occurring in a gaseous state at ambient temprature and pressure (principally methane).

Retrofitting: Installing an energy saving device or process (or an alternative type of boiler) after a plant has begun operating.

Energy Conversion Factors[3]

Throughout this study (except where other works are cited) the energy unit used is metric tons of coal equivalent (mtce). This was chosen because the UN uses this same energy unit in its publications and hence lends itself for inter-country comparison. Moreover since individual fuels may vary significantly in calorific value based on source of supply, there is no universally agreed system of conversion from one unit to another. In the absence of exact knowledge of the source of supply and corresponding calorific value, and the fact that supply sources have been changing over time we have chosen to stick to UN conversion factors

For Conversion to Metric tons of Coal Equivalent (Mtce)

1 metric ton of oil equivalent	=	1.47 mtce
1 barrel of oil equivalent	=	0.21 mtce
1,000 kwh of electricity	=	0.123 mtce
1 exajoule	=	34.13 million mtce

Metric Multipliers

kil	10^3	tera	10^2	Mega	10^6
giga	10^9	quad	10^{15}	exa	10^{18}

1 metric ton = 7.353 barrels

1 metric ton = 1169.127 litres

Adopted from

[1]UNESCO, B ulletin of the Regional Office for Science and Technology for Africa, (Nairobi, Kenya, Vol. XVI, No. 3, July - September 1981) pp. 1 - 2

[2]World Bank, Energy in the Developing Countries (Washington D.C. August 1980)pp. iv - v. World Bank Renewable Energy Resources in the Developing Countries (Washington D.C.: January 1981) pp. ii - iii.

[3]United Nations, World Energy supplies 1950 - 74, (New York, Series J. No. 19, 1976)

ACRONYMS AND ABBREVIATIONS

CE	Commercial Energy
CEC	Commercial Energy Consumption
GDP/Cap	Gross Domestic Product per Capita
IND/Cap	Industrial Portion of GDP/CAP
Tran/Cap	Transport Portion of GDP/CAP
Agr/Cap	Agricultural Portion of GDP/CAP
CSO	Central Statistical Office
CPSC	Central Planning & supreme Council
EPC	Ethiopian Petroleum Corporation
EELPA	Ethiopian Electric Light and Power Authority
OPEC	Organization of Petroleum Exporting Countries
Mtce	Metric tons of coal equivalent
KgCe	Kilograms of coal equivalent
KWH	Kilo Watt Hours
MW	Mega Watt s
GC	Gregorian Calendar
EC	Ethiopian Calendar
LDC	Less Developed Countries
LF	Liquid Fuel
LFC	Liquid Fuel Consumption
MT	Metric ton
MVA	Mili Volt Ampere
NBE	National Bank of Ethiopia
GWH	Giga Watt Hours
ENEC	Ethiopian National Energy Commission
MGP	Mogas Premium
MGR	Mogas Regular
AGO	Gas Oil
CF	Conversion Factor
SWRL	Shadow Wage Rate of Labor
SCF	Standard Conversion Factor
LPG	Liquified Petroleum Gas
TWH	Tera Watt Hour
R & D	Research and Development

INTRODUCTION

1.1 Background

The 1973-74 OPEC price increase has ushered in a new era; an era in which the problem of energy has become an overriding problem and a challenge to nations, developed and developing alike. The problem is undoubtedly more serious for the latter, since it came at the most crucial time in their development effort, denying them the historical opportunity of basing their industrialization on such versatile energy source as petroleum. To date, the economic development of the industrialized countries was fueled by cheap energy supply. Such cheap energy supply can now largely be regarded as a thing of the past. Instead it is the spectre of ever rising energy cost that is haunting the LDCs. After the initial shock, subsequent price increases have worsened the already shaky economic foundation of these countries. High oil import bill has led to the widening of the balance of payment deficit, dramatic increase in external indebtedness, slowing down of economic growth rate, excessive rates of inflation etc., turning what was already a grave situation into a nightmare. It is this debilitating effect that the sudden quadrupling of oil has brought on all facets of economic life of countries like Ethiopia that has led us to consider the energy problem on the scale of crisis.[1] Our use of the term crisis is thus rather limited to its effect on domestic economic variables and should not be equated with the issue of "world energy crisis". On the supply side the problem is no more caused by physical shortage of energy sources than the "artificially contrived scarcity generated by the international oil companies and oil producing countries"[2]. Regardless of the cause (an issue that would take far more space than we care to devote for) the havoc that high cost of oil is causing to the eocnomies of poor countries is very real and the high oil price need to be viewed seriously and its effect on both short and long term development policies assessed accordingly. True enough the price of oil is currently drawing a declining trend after hitting a record level of 40 US dollars per barrel in 1979. This downward trend, mainly as a result of the glut of oil in the world market has led some people to view it as a reversal of the trend in the 1970s. Though indicative of the "limited" power of OPEC (in its arbitrary measures in raising prices), we don't entertain the possiblity of taking the golden path back towards the era of cheap energy supply. In the absence of adequate substitute for such versatile energy source as petroleum,we feel that oil producing countrie do posses the monopoly power to combat any marked decline in price and in the years to come to influence, prices upward, albeit not as dramatic as those of the 70's. The recent agreement of OPEC to reduce their daily output underscores this very point.

The stepped up conservation and demand management measures by oil importing (largely industrialized) countries and the slowing down of economic activity in general have led to the current oil glut. The underlying reason for increased demand for oil (ie. increased economic activity, especially that of LDCs whose demand though small in absolute terms is growing at a fast rate) and the monopoly power of OPEC however remains . Thus the picture one gets of the secular trend is not one of a decline but rather an upward movement with some periods of stagnation or even relative decline,but followed by an increase showing a kind of spiral movement. It is this view of rising price (though relatively rather modest) that we hold as prudent, and employ all through our analysis.

It should be noted here that the 1973-74 oil price increse was among the factors that ignited and served as a pretext for the revolution to erupt in Ethiopia . But whereas many of the factors that were hampering the country's development effort were tackled by the revolutionary measures enacted, the problem of commercial energy (CE), (particularly petroleum) being mainly an exogneous factor has persisted and has continued to pose a great challenge to the nation. To make matters worse, the problem regarding CE sources came at a time when the traditional energy sources are in critical situation. The traditional energy sources which meet 96% of the country's energy demand are today being depleted faster than they are being restored, posing no less threat to the nation. Wood which used to be " a poor man's oil" and was inadvertently seen as being of "limitless supply", is fast becoming a very expensive commodity. Generally the grave environmental, social and economic consequences that could follow from such rapid depletion of forests has made a careful and judicious management of this important resource imperative. This being the case, one can in fact say that Ethiopia is in what may be called a "double energy crisis".

Despite the fact that the real extent of the energy problem could be appreciated by examining both the traditional and CE sources, lack of data has forced the writer to concentrate on CE sources alone (except in chapter 4 where an overall view of the country's potential sources is assessed), Which in Ethiopia are petroleum and hydroelectricity, with the former accounting for over 93% of CE consumed. Notwithstanding its small share in total energy (about 4%), if seen in the dynamic context of economic devleopment, study of CE alone may prove very useful since it virtually deals with the modern sector of the economy which could rightfully be taken as the spearhead for socialist construction. Moreover, though small in magnitude, CE is largely used for productive activities unlike the traditional energy which is mostly used for direct consumption; (cooking, heating etc.) .If so, then smallness cannot be identified with unimportance. In fact it is only such an approach that could throw light into the country's future energy needs and the problems there of. Because sooner or later, development would mean replacing handicrafts with factories, peasant agriculture with tractors, pack animals with lorries etc. This in general implies the use of modern equipments and technologies which are energy intensive and hence create a rising demand for CE. Furthermore an increase in the standard of living will lead to the gradual substitution of traditional and animate forms of energy by CE sources.

It is however important to point out here that the above remark is not meant to imply that developing countries should (or could) follow the same development pattern that the present developed countries did. High population growth rate, the relative scarcity of raw materials, the monopolized foreign market excessively high prices for import of capital goods, relatively low price for their exports in the face of rising energy cost etc. and currently the weakness of import growth in the industrialized countries as a result of the slowing down of economic activity of the latter makes such a pattern neither possible (at least in the short run) nor desirable. What they need is rather a development pattern that is less energy intensive and more efficient in its utilization. This will later in the paper lead us to reconsider the relationship between energy, technology and development in light of expensive energy input.

Whichever pattern is followed however, demand for CE is bound to increase with economic development. What one can at best hope for is therefore to affect (reduce) the rate of growth of CEC and not reduce the absolute magnitude. If so, the increasing demand for CE and associated rising cost highlights the need to examine the relationship between CEC and economic development, to assess the country's energy potential, and to carefully plan energy production and consumption in line with long and shor term development objectives of the country. In short the critical condition we are in with respect to CE makes increased attention by policy makers, planners, and academicians imperative,

1.2 Objectives of the Paper

Within the context of the foregoing discussion the broader objective of this paper is to provide insight into the relationship between CEC and economic development in the belief that it will help in the formulation of development policies, energy specific or otherwise. The specific issues that the study addresses itself to are:

1. To examine the existence and if so, the degree of relationship between Commercial Energy Consumption per capita (CEC/cap) and Gross Domestic Product per capita (GDP/cap). To get better picture of the sectoral consumption, the same will be examined, between CEC/capita on one hand and Industrial,Agricultural, Transport portion of GDP/capita (Ind/cap, Agr/cap, Tran/cap) respectively, on the other. We believe that establishment of such relationship will throwmuch light on the impact that supply shortage could have on economic growth.

2. To assess the impact of rising energy cost on the country's balance of payment, economic growth rate and inflation rate. Regarding the former, factors that operate both on the export and import side will be examined to draw a rough picture of the magnitudes of future problems if the present unhealthy trend is to continue.

3. To attempt demand projection for CE and the associated level of foreign exchange requirement. Given the important role of CE in economic development, comparable to capital and skilled labor, and taking into account the fact that projects to be executed to improve supply situations take a very long time to mature, the findings will help to emphasize the timely need for policy to adequately forecast future needs so as to meet the investment requirement in time.

4. To recommed policy options that will help reduce rates of oil consumption, curb import growth and anable increased move towards exploitation of indigenous energy sources etc.

1.3 Methodology:

Regression analysis - both time series and cross sectional will be used in the analysis of the relationship between CEC and economic development as well as to the make projection of future energy demand. The period under consideration in the time series analysis runs from 1958 to 1973 E.C.; a total of 16 years. The cross section is used only for the comparative analysis between countries.

Since many of the factors that have been affecting economic development in Ethiopia over the past few years were non-economic in nature (war, drought, etc.) , an effort will be made to supplement the empirical results with historical analysis, To this extent, the approach will be descriptive.

1.4 Significance of the Study:

Very few empirical studies are made in LDCs to show the extent of relationship between CEC and economic development. In Ethiopia too, except for some rough projections made by Central Planning Supreme Council (CPSC) and reports on the energy problem by Ethiopian National Energy Commission (ENEC) and some foreign consultants etc., no such analysis have so far been made. This is largely attributed to lack of data. But failure to attempt investigation on the ground that there is lack of data begs the question since data to some extent are always lacking and that a start has to be made somewhere for others to improve on.

Needless to say , cross section studies made by international organizations and available imformation in the country (scanty and unrealiable as they are) can serve as a spring board for one to make the venture. Such a study though lacking in many respects can serve as a basis for decision making in this turbulent period of economic development. Finally, I hasten to add Hirschman's view (which I support) that "at this stage, the paucity of testable hypothesis has become an even more serious bottleneck in studying economic development than the shortage of data. Hypotheses beget data"[3] and since the implicit objective of this paper is to make a modest contribution for others to improve on, it is my sincere hope that the propositions held here will in future be subjected to critical empirical research.

Data Sources and Limitations

Data regarding CEC are largely gathered from Ethiopian National Energy Commission (ENEC), Ethiopian Electric Light and Power Authority (EELPA); Ethiopian Petroleum Corporation (EPC). Figures of GDP,price index etc are obtaine from Central Planning and Supreme Council (CPSC) Central Statistical Office (CSO) and National Bank of Ethiopia (NBE). Both published and unpublished records are used.

In the assembly of time-series data, absence of uniformity for the different variables presented some difficulties. While organizations like EPC keep their data according to Gregorian Calendar (GC), CSO,CPSC etc. assemble their data on the basis of Ethiopia Calendar (EC). For regression analysis uniformity of data base was essential.

In the attempt to resolve the problem, it was found out that for most of the years under study, EPC has data on monthly basis. These were used to convert the figures to EC. For some three years however, we had to divide the yearly figures and convert accordinly. For example, to get the figure for 1960 E.C. which is 1967/68 G.C. we took half of 1967 and half of 1968. We cross checked whether there is seasonality in the data flow that could grossly distort the figures so obtained by doing the same to the years for which monthly data was available and found out the difference to be marginal to affect our analyses.

For the rest of the analysis, conversion was not found to be necessary. As a result both calendars are interchangeably used depending on the original data. To avoid redundancy only years pertaining to EC are so indicated. Therefore, unless and otherwise specified, all years are according to G.C.

Structure of Report

In the belief that establishing the relationship between CEC and economic development would give a firm foundation to the conclusions and policy recommendations to be derived we will start be examining the existence of relationship and determining the degree of relationship. First correlation analysis between CEC and GDP as well as the various portions of GDP will be made based on time series data. To give more weight and clarily to the findings of the time series, and to be able to make inter-country comparison, the analysis will be repeated, this time based on cross section data of different countries of the world. Effects of the price increase on the countries balance of payments, economic growth rate and inflation rate will also be examined.

In Chapter 3 we will discuss the supply and demand conditions of CE (electricity and petroleum) along with other related problems like distribution, capacity etc. Demand projection for the coming 10 years will also be made. Part four, which can be considered as part two of the paper looks at the foundations of sound energy policy for the country. First problems related to pricing and fiscal policy will be examined. Conservation policy will then be discussed, as a short-term measure that could help to reconcile energy requirements with competing claims of different economic sectors. The last two parts will deal with a relatively longterm policy measures regarding energy supply and demand. The first looks at the possiblity of shifting towards increased use (exploition) of indigeneous energy resources along with the ease or difficulty of it. The second i.e. chapter 5 examines the relationship between energy, technology and development in light of expensive energy input and suggests possible strategy of development.

2.0. CEC and Economic Development

Economic development largely depends on the raising of the average productivity of labour. The growth of the latter is on the other hand intimately linked to or rather a direct function of the amount of energy used and the form that such energy assumes. As a result the amount and form of energy that different societies employ can be taken as an indication of the degree of development attained. Historically, man's epoch changing activities have always coincided with development of different sources and forms of energy. Such develpments have moreover been leading to a more energy intensive world. Fire, the first and by far man's greatest discovery provided the energy source which enabled him to increase his productive capability-i.e., in smelting iron to make ploughs, spears etc. Subsequently, increased use of animate energy, (cattle for cultivation, pack animals for transporting goods) wind power for pumping, water power for milling etc., further enhanced his ability and knowledge to harness and make use of various forms of energy. The greatest stride in this regard came with the first industrial revolution which came based on the use of steam engine. Further still, the second industrial revolution came based on a still different source and form of energy; this time on electrical energy and internal combustion engine. It is at this juncture that petroleum starts to assume an increasingly important role as a source of energy, gradually usurping "kingship" from coal. Though at slow pace, the third industrial revolution is currently underway based on the release of nuclear energy and the use of electronic machinery.

GNP/capita and CEC/cap for Selected Countries of the World

Table 2.0.0

HIGH INCOME CATEGORY			MIDDLE INCOME CATEGORY			LOW INCOME CATEGORY		
COUNTRY	GNP/cap in US $ 1978	CEC/cap in Kgce 1978	COUNTRY	GNP/cap in US $ 1978	CEC/cap in Kgce 1978	COUNTRY	GNP/cap in US $ 1978	CEC/cap in Kgce 1978
Italy	3850	3230	Liberia	460	395	Ethiopia	120	20
USSR	3700	5500	Egypt	463	463	Chad	140	22
Hungary	3450	3451	Thailand	490	327	Burma	150	64
Great Britain	5030	5212	Peru	740	649	Guinea	210	91
Japan	7280	3825	Columbia	850	700	Benin	230	56
France	8260	4360	Jordan	1050	535	Tanzania	230	65
U.S.A	9590	11374	Jamaica	1110	1823	Afghanistan	240	47
			Argentina	1920	1873	Haiti	260	57
			Mexico	1290	1384	Kenya	330	139
						Indonesia	360	278

Source: World Development Report, 1980.

It is therefore not surprising to find that the amount and form of energy consumed could by and large indicate the level of economic and social development attained by different countries. Table 2.2.0 indicates the relationship between per capital consumption of EC in kilograms of coal equivalent (Kgce) and per capital income in US dollars for 1978 for a set of 26 countries, classifed under throe income categories.

The foregoing Table amply demonstrates that a low level of CEC coincides with low income levels, and that the more developed countries are at the same time those with the highest consumption levels. In fact some studies indicate that "a country with 10 times the national income of another has 26 times the fuel consumption."[1]

Not only is CEC related to level of income but is also highly related to it more than any other development indicator ($r_s = 0.9679$). Table 2.0.1 shows rank correlation made to this effect for some selected countries.[2]

Table 2.0.1

Spearman's Rank Correlation Coefficient (r_s); Per Capita Income correlated to Socio-Economic Indicators.

	r_s
CEC per capita	= 0.9679
Contribution of Agriculture to GDP	= -0.9411
Contribution of Industry to GDP	= 0.8143
Physician per Population	= 0.7393
Crude Death Rate	= -0.7017
Life Expectancy at Birth	= 0.9589

Daily Caloric Intake	=	0.8214
Adult Literacy Rate	=	0.8964

Source: Computed based on data from World Development Report, August 1980.

Admittedly, many factors do contribute to the economic progress of nations. Energy is however taken to be the sine-qua-non of economic development. Deservedly so, since energy - CE in particular- is at one and the same time used as a direct consumer good contributing to people's material welfare and as input in all types of modern production process.

2.1. CEC and Economic Activities

Many studies have been made over the past years (specially after the 1973-74 price hike) to determine the relationship between CEC and economic and social development. One such study was made by John G. Leigh et. al. The study took 112 LDCs (Ethiopia included) and performed regression analysis.[3] Some of the conclusions arrived at are:

- Per capita CEC is positively and significantly related to GNP per capita and also to the industrial portion of GNP per capita, while no such significant relationship exists between CEC and the agricultural portion of GNP per capita.

- Total liquid fuel consumption (LFC) is negatively correlated with the change in growth rates for oil importing LDCs. The study then goes on to indicate the existence of a very strong causal link between the petroleum price rises of 1973-74 and the subsequent deterioration in the economic performances of LDCs. Accordingly

- Real GNP/capita growth rate dropped by more than half (from 3.1% to 1.5%) after 1973.

- Inflation rates more than trippled (from 7.7% to 24.5%) after 1973.

- Real balance of payments deficits nearly trippled after 1973.[4]

Similar studies were also made by the World Bank, United Nations, etc.[5] Studies made by UN agencies for Latin Amarica and Asian countries also indicate the existence of such strong relationship between CEC and economic activities.[6] Nonetheless, apart from studies made for industrialized countries, where time series analysis has shown high correlation between GDP and CEC, few such studies exist for LDCs like Ethiopia, mainly on account of an insufficient data base.

2.1.1. <u>Relationship of CEC with GDP</u>.

In what follows we will attempt to measure the extent of the relationship between the variables indicated based on time series data - (1958 - 1973 E.C.). The functional relationships used for this part are largely similar to those employed by Leigh et al.; except that here time series data are used. We believe that time series provide better results on many accounts. CEC is influenced by factors other than level of GDP; factors that show considerable variation between countries. For instance an economy based on mineral wealth will need large amount of CE per unit of product than say an agricultural country. The dominance of certain industries (cement production, iron smelting, etc.), degree of electrification and urbanization, consumer habits, income distribution, cultural orientation, climate, etc., are also known to influence CEC.[7] Extent of such variation (or factors) within a certain goegraphic boundary is relatively very low.

Models Tested

Two models are used for the analysis. These are:

$$Y_t = \beta_0 + \beta_1 C_t + \mu \quad \ldots \quad 2.1a$$

$$Y_t = \beta_0 C_t^{\beta_1} \mu \quad \ldots \quad 2.1b$$

where,

C_t is CEC per capita(CEC/cap) in Kgce.

Y_t is GDP per capita (GDP/cap) in birr, constant 1953/54 E.C.

β_1 in model 2.1a measures incremental (marginal) variation of GDP with CE while β_1 in model 2.1b measures elasticity of CE. The two are related. Multiplying the former β_1 by the ratio of the variables ($^{ct}/yt$) will give us the elasticity of CE.

Similar regression on C_t by using various dependent variables was also made. Variables used are agricultural, industrial and transport and communications portions of GDP/cap (designated as Yag, Yind, Ytran respectively).

In order to see the relation of liquid fuel consumption (LFC) in isolation, additional runs were made in a parallel manner, by replacing the independent variable C_t by F_t (LFC per capita).[8]

Table 2.1.0 Results of Regression of GDP/cap on CEC/cap.

MODEL USED	Analysis	Dependent Variable	Independent Variable	Intercept β_0	*Coefficient β_1	Standard Error β_1	R^2
$Y_t = \beta_0 + \beta_1 C_t + \mu$	First Analysis	Y_t	C_t	107.46	1.423	0.226	0.74
		Yag	C_t	78.62	-0.264	0.321	0.05
		Yind	C_t	9.32	0.529	0.065	0.83
		Ytran	C_t	-0.34	0.367	0.068	0.68
$Y_t = \beta_0 C_t^{\beta_1} \mu$		LY_t	LC_t	1.806	0.251	0.035	0.79
		LYag	LC_t	1.987	-0.094	0.109	0.05
		LYind	LC_t	0.540	0.582	0.073	0.82
		LYtran	LC_t	-0.678	1.162	0.205	0.70
$Y_t = \beta_0 + \beta_1 F_t + \mu$	Second Analysis	Y_t	F_t	105.92	1.582	0.230	0.77
		Yag	F_t	77.08	-0.214	0.353	0.03
		Yind	F_t	8.88	0.583	0.067	0.85
		Ytran	F_t	-0.27	0.388	0.078	0.64
$Y_t = \beta_0 F_t^{\beta_1} \mu$		LY_t	LF_t	1.815	0.249	0.035	0.79
		LYag	LF_t	1.960	-0.076	0.109	0.03
		LYind	LF_t	0.552	0.585	0.069	0.84
		LYtran	LF_t	-0.591	1.120	0.216	0.66

*Except for Yag, i.e., agricultural portion of GDP/cap, which shows no statistically significant relationship all the rest are significant at the 1% level.

The prefix "L" stands for the logarithm of the variable as defined above.

Both models indicate that CEC is strongly and positively related to all the dependent variables except for Yag (Agr/cap). This latter result reflects the dominance of peasant farming and the highly subsistence nature of the rural economy, whose need for CE is very minimal. For those variables that showed significant relationship, the degree of correlation was more strong for Yind (Ind/cap) closely followed by Yt (GDP/cap)[9] and Ytran (Tran/cap). The relatively low degree of relationship obtained for the latter at first looks counter-intuitive, since it happens to be the highest consumer of CE. One reason for such an outcome is the lumping of transport with communications under one category, which we feel dampens the strength of the relationship. Secondly, the share of transport in GDP is apt to be underestimated since in the productive activities - industry, agriculture, etc. - contribution corresponding to transport may not be isolated. The very small (almost zero) value of the intercept confirms the absolute necessity of CE input for output to be forthcoming.

Almost an identical result is shown by the second part of the analysis, where Ct (CEC/cap) is replaced by Ft (LFC/cap). Given the very high share of LF in CE (about 93%) such a result is to be expected.

In the belief that it would lend substantial contribution to the explanatory power of our model and cognizant of its crucial role in economic development we included Gross Domestic Investment per capita (It-1) into the third round of our regression.[10]

$$Y_t = \beta_0 + \beta_1 C_t + \beta_2 I_{t-1} + \mu \quad . . . \; 2.1C$$

where,

I_{t-1} is lagged GDI/cap.

GDP/capita regressed a CEC/cap and Gross Domestic Investment/cap
(Third Analysis)

Table 2.1.1

MODEL USED	Dependent Variable	Independent Variable	Intercept $\hat{\beta}_0$	Coefficient $\hat{\beta}_1$	Standard Error of $\hat{\beta}_1$	R^2	F Value**
$Yt = \beta_0 + \beta_1 C_t + \beta_2 I_{t-1} +$	Yt	Ct It-1	101.201	1.445 0.332‡	0.223 0.271	0.77	21.30
	Yag	Ct It-1	53.321	0.159‡ 1.341	0.135 0.164	0.84	35.23
	Yind	Ct It-1	6.012	0.543 0.175*	0.055 0.066	0.89	50.57

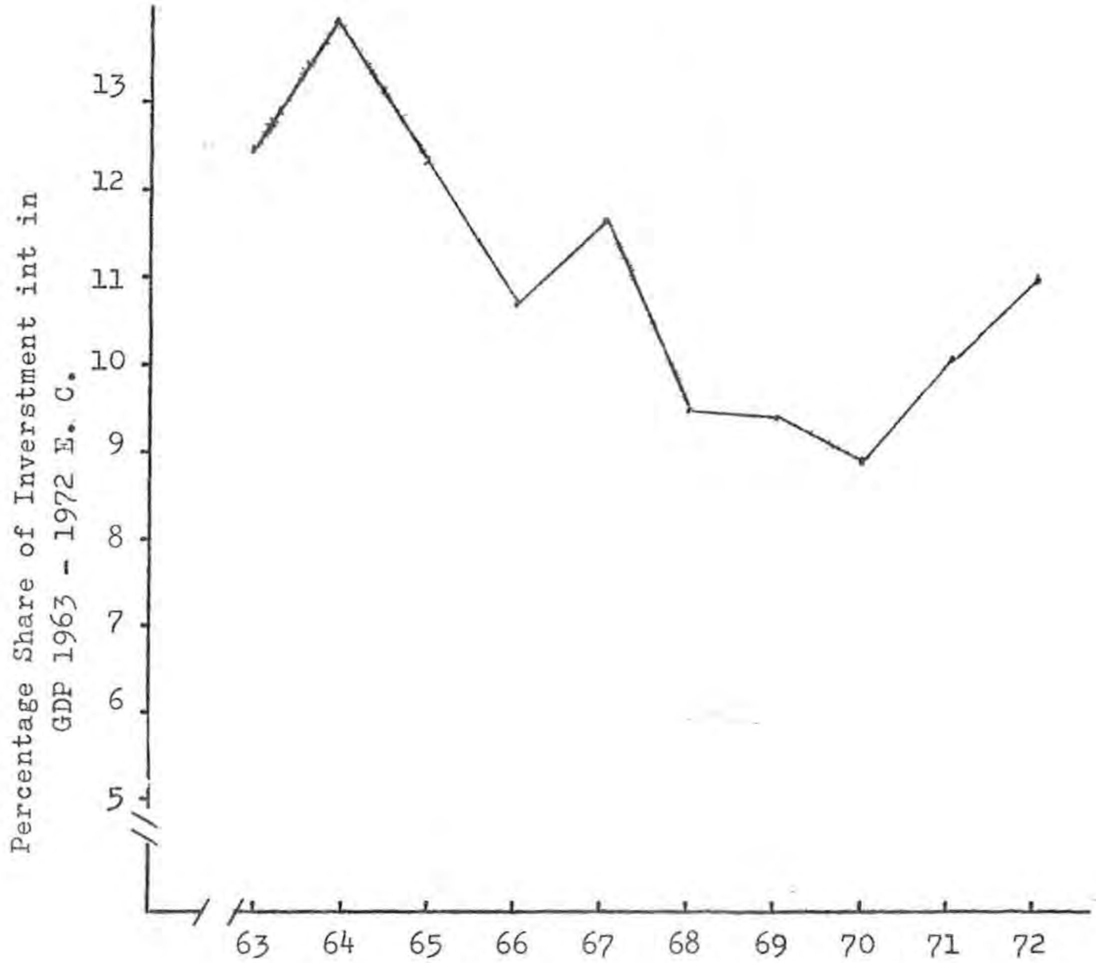
‡ shows no statistically significant relationship.
* Significant at 5% level.

The rest are significant at 1% level.
**Significant at 1% level.

As shown in Table 2.1.1, the multiple regression indicates no significant relationship between Yt (GDP/cap) and It-1 (GDI/cap)[11] and positive relatiohship with Yag (Agr/cap)[12] and Yind (Ind/cap)[13], with stronger relationship with the former.

The absence of significant relationship with Yt is in a way a reflection of the overall low capital formation of the country. To dwell more on the subject of interest, the low investment in the energy sector and the consequent dependence on imported oil, is also explained by this low level of overall investment. In the 1970s the developed countries used on the average 23-25% of their GDP for investment while for the LDCs the comparable figures was on the average 14%.[14] In Ethiopia, not only is the share of investment below this low level but infact shows a declining trend.

Figure 2.1.0 Percentage Share of Investment in GDP 1963 -1972 E. C.



Source: CSO Statistical Abstract 1978. Figures for 1970 and 1971 are from CPSC.

Such a low level of investment is indeed a cause for concern. What is more serious or rather unfortunate is the fact that we have to undertake the painful process of capital accumulation at this juncture, when high energy cost is making the burden increasingly difficult to bear.

As an alternative to the above approach we have made a cross section analysis of the same variables based on data for African countries. It is the belief that having more or less similar production structure and economic problems, would show better comparable result that we took only African countries. Two periods 1975 and 1977 are taken for analysis.[15] The model employed is similar to the time series.

$$Yi = \beta_0 + \beta_1 Ci + \mu \quad . \ . \ . \ . \ . \ .$$

where,

Yi = GNP percapita in 1975 and 1977 US$

Ci = CEC percapita in Kilograms of Coal equivalent.

$i = 1, 2, 3, \ldots, 27.$

Table 2.1.2 below summarizes the result obtained.

GNP/cap regression on CEC/cap for 27 African Countries

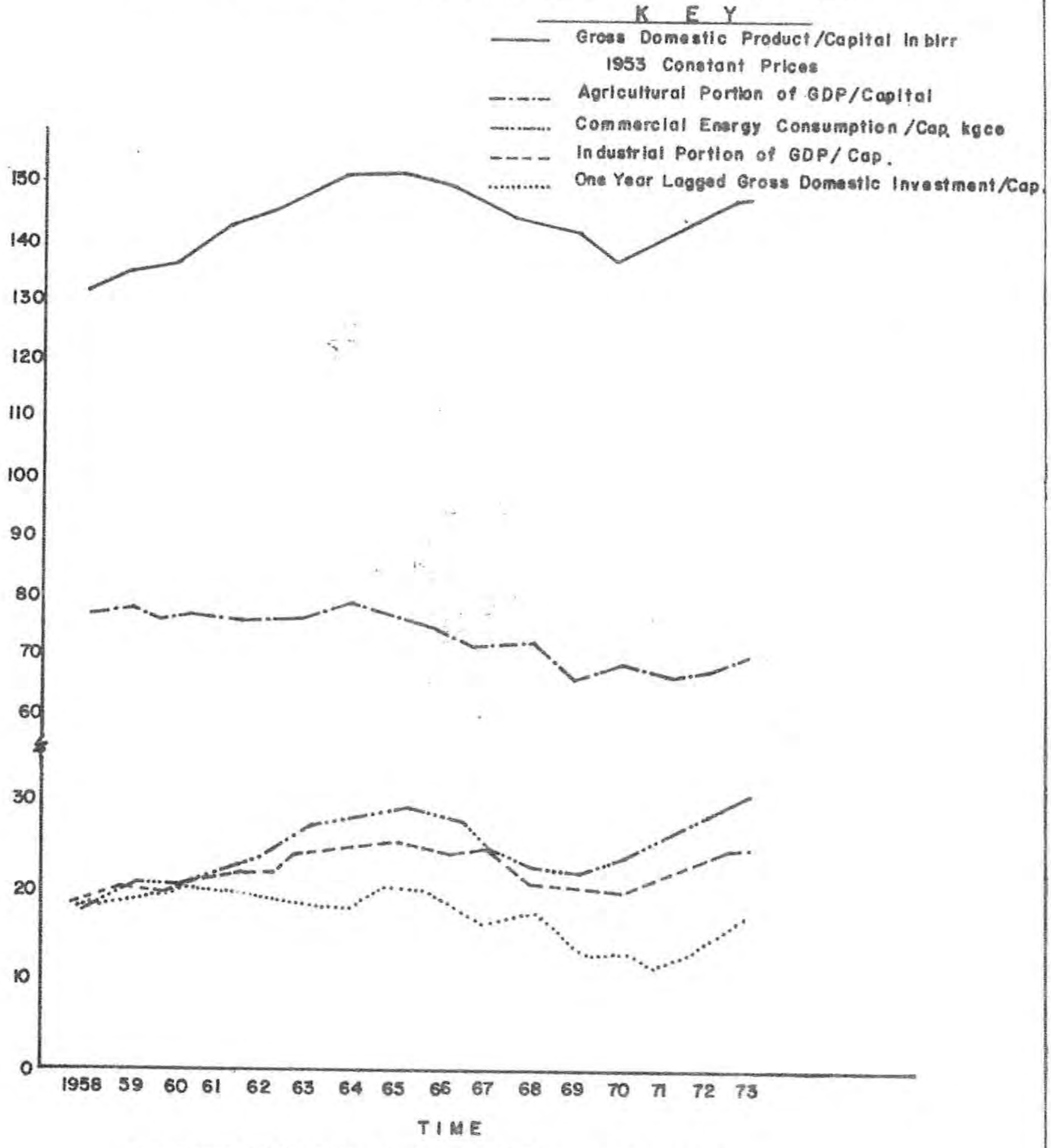
Table 2.1.2

YEAR	Dependent Variable	Independent Variable	Intercept $\hat{\beta}_0$	Coefficient $\hat{\beta}_1^*$	Standard Error of $\hat{\beta}_1$	R^2
1975	GNP/cap	CEC/cap	164.A	0.767	0.130	0.58
1977	GNP/cap	CEC/cap	166.0	0.774	0.127	0.60

* Both are significant at the 1% level.

Results obtained both in the time series and cross section analysis clearly indicate existence of strong relationship between GDP/cap and CEC/cap.

Figure 2.1.1 Trends in Economic Variables 1958—1973 E.C.



Sources: CSO, NBE. Data for 1973 are planned figures

Before concluding this section, a brief discussion on the impact of non-economic factors would be in order. Figure 2.1.1 shows the extent to which the economy has suffered due to disruption of normal economic activities following the revolution. All economic indicators plotted against time show a dip for the few immediate years after the revolution and a joint rise with the coming of a relatively stable period.

It is quite evident that such events like the war in the Ogaden, and Eritrea, civil disturbances in Addis Ababa and other major cities, the various campaigns against landlords who took to the forest, etc., have all contributed in one way or another towards the disruption of economic activities. Diversion of economic resources to the war effort - a sacrifice made to defend the revolution and maintain the unity and territorial integrity of the nation-and the drought that repeatedly hit various provinces were also additional factors. The radical economic and social reforms that the government undertook during this period, measures like nationalization of rural land, urban land and extra houses, the nationalization of major industries and financial institutions, the various systems of price, credit and foreign exchange controls etc., have all lead to temporary dislocation in economic activities both in the spheres of production and distribution. In short many factors have affected all economic variables. Now that such effects are wearing out we expect an increase in economic activities and with it an increase in demand for CE.

2.1.2 Inter-country comparison of CEC and GNP

Results obtained above, though quite indicative of the degree of relationship between CEC and economic development, do not tell (determine) what could be considered as an adequate consumption level in relation to the degree of development. Establishing such optimum level of consumption involves a much deeper and comprehensive research into the structure of the economy, sectoral consumption pattern, type and efficiency of technology employed, etc., issues which are beyond the purview of this study. However, to leave the issue aside would also be a gross failure. We will therefore attempt to tackle the problem by taking an easier, albeit a second best approach, via drawing comparisons between different countries.

Since energy used for direct consumption by the population depends on purchasing power (a fact reflected in per capita income), and given that the energy consumed in the production process is dependent on the volume of production (measured in GNP), per capita income can be used as a fairly good index for reflecting the economic potential and degree of general development of a country. Cognizant of this, we have made inter-country (cross-sectional) analysis based on data of 114 countries of the world divided into four groups - low income, middle income, industralized and centrally planned countries - according to World Bank classification.[16]

The model used is :

$$\ell n \, CEC/cap = \ell n \, \beta_0 + \beta_1 \, \ell n \, GNP/cap + \mu$$

where, CEC/cap and GNP/cap are in Kgce and US$ in 1978 respectively.

As shown on table 2.1.3 below and in figure 2.1.2, there is strong relationship between the variables with centrally planned countries showing the highest, followed by middle income, low income and industrialized countries in that order.

Regression of CEC/cap on GNP/cap for four groups of countries

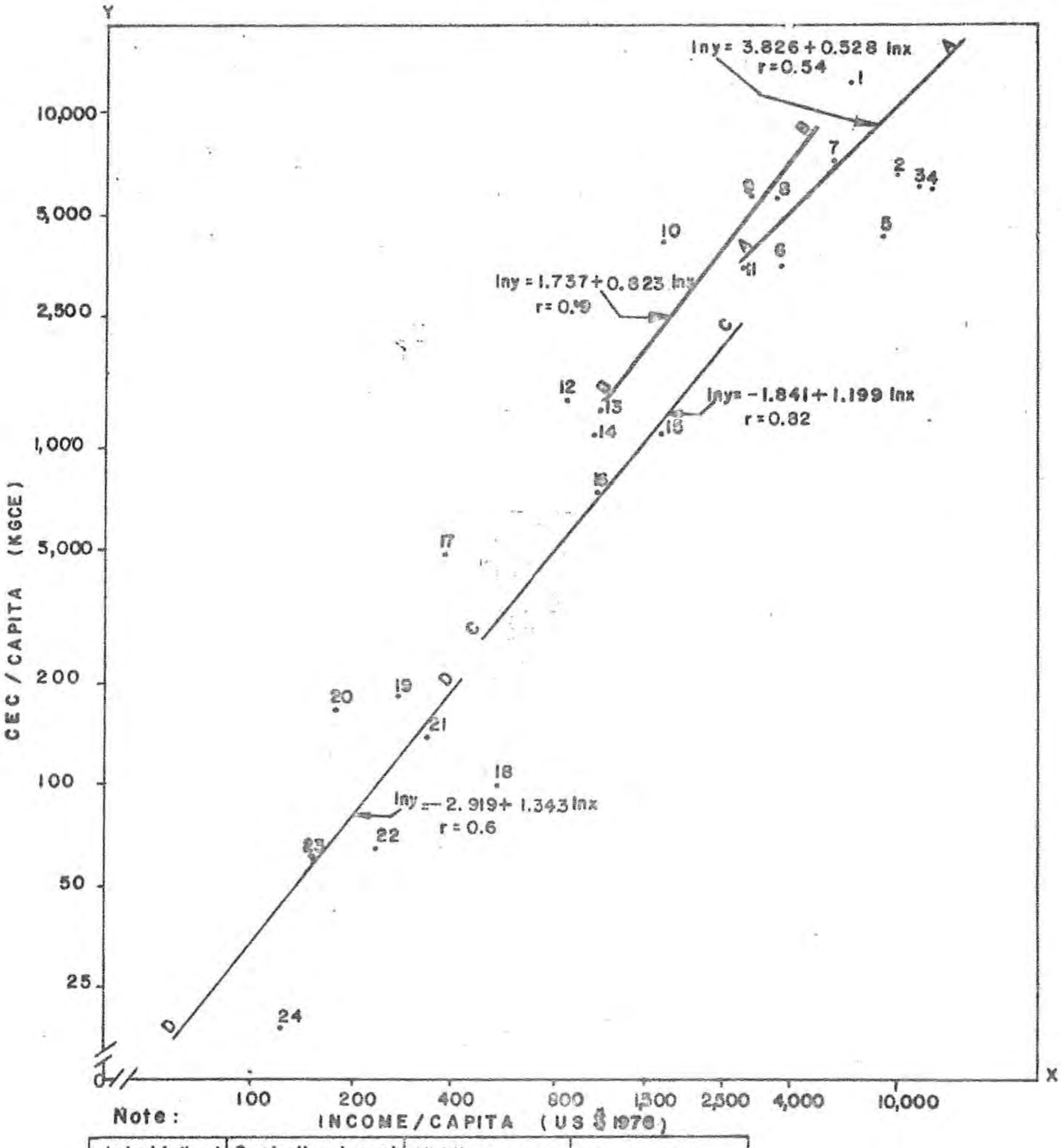
Table 2.1.3

COUNTRY GROUP	Dependent Variable	Independent Variable	Intercept β_0	Coefficient β_1	Standard Error of β_1	R^2
Low Income	ℓnCEC/cap	ℓnGNP/cap	-2.919	1.343	0.311	0.36
Middle Income	ℓnCEC/cap	ℓnGNP/cap	-1.841	1.199	0.118	0.68
Centrally Planned	ℓnCEC/cap	ℓnGNP/cap	1.737	0.823	0.131	0.81
Industrialized	ℓnCEC/cap	ℓnGNP/cap	3.826	0.528*	0.207	0.29

*Significant at 5%; the rest at 1% level.

The result obtained is by and large in line with the generally held hypothesis; that first, at low stage of development energy consumption grows less intensively than the gross product and later at intermediate stage of development, i.e., when "pronounced changes take place in the form of an increased expansion of industry and other activities whose input of energy is proportionally higher" and when with increased standard of living house holds increasingly shift from animate and traditional form of energy, CEC shows increased rate of growth per unit of product. Later at more advanced stage of development

Figure 2.1.2. Regression between Commercial Energy Consumption and Gross National Product/Capita for four groups of Countries 1978 (Natural Logarithm Scale)



Note:

Industrialized Countries (A)	Centrally planned Countries (B)	Middle income Countries (C)	Low income Countries (D)
1) USA	7. GDR	13. MEXICO	19. ANGOLA
2) BELGIUM	8. USSR	14. TURKEY	20. PAKISTAN
3) F.R.G	9. POLAND	15. BRAZIL	21. KENYA
4) SWEDEN	10. ROMENIE	16. EGYPT	22. TANZANIA
5) FRANCE	11. HUNGARY	17. MALAYSIA	23. BURMA
6) ITALY	12. CUBA	18. [illegible]	24. ETHIOPIA

when "production sectors acquire a more stable structure", we again see a less intensive growth "this time because of the possibility of more efficient utilization of energy and the partial saturation of household consumption."[17] (See figure 2.1.3 below)

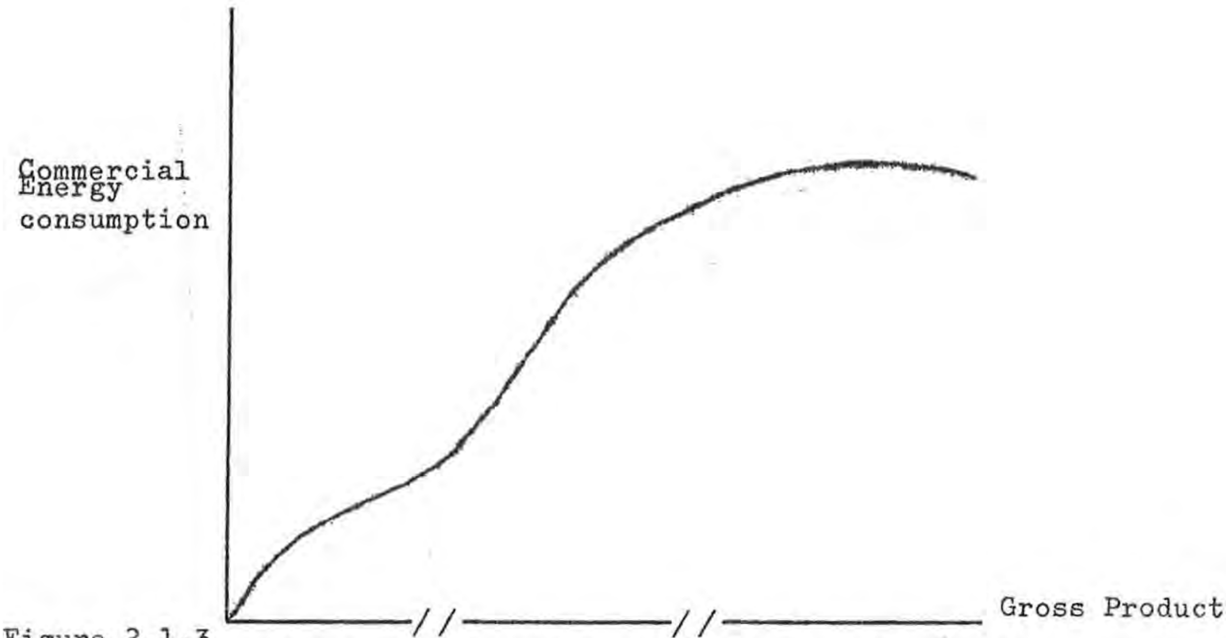


Figure 2.1.3 Behavior Pattern of the Relationship between CEA and Gross Product

As summarized in the table, higher GDP elasticity of demand for CE is shown by low income countries followed by middle income, centrally planned and industrialized countries. The result thus indicates that the low income and the middle countries are in the stage of development where CEC shows increased rate of growth per unit of product. The product elasticity of centrally planned countries (less than unity) indicates the fact that they are well into the transition from increased rate of growth of CEC per unit to a less intensive one, reflecting "more efficient utilization of energy and the partial saturation of house hold consumption." The low product elasticity of industrialized countries (considerably below unity) further shows the very high efficiency level attained by these countries.

From the above, one can easily discern a picture of the behavior pattern of the relationship between CEC and economic growth. If so, it should be possible to get at least a rough idea (by making projection) of the amount of CE required for a planned level of GDP and accordingly explore supply possibilities in time, to duly meet the projected demand.

Here is a very illustrative picture that relates future level of development with the energy requirement. For Ethiopia to reach a level of development comparable to that of Cuba (see figure 2.1.2) it would need to maintain a compound growth rate of 10% per annum for the next 20 years; and assuming similar production structures, the concomitant energy requirement would be inter alia:

An annual crude oil import of around 3 million tonnes at a cost of US$ 1 billion, at constant 1981 prices,

Investment of US $2.5 billion for refining and distribution and US $ 20 billion (of which $15 billion is foreign exchange) to install electrical generating capacity of 20 GW.[18]

Staggering and awe-inspiring as the above illustration is, it has only managed to barely capture the tortorous and rather painful course of development when one considers the fact that Cuba itself is a relatively less developed country (with a per capita income of US $810 in 1978), when compared to some middle income countries like Mexico, Brazil, Turkey, etc., all with a per capita income of well over US $1000 for the same period, and obviously much less so when compared to industrialized countries like the U.S., F.R.G., Sweden, etc., all with a per capita income nine times that of Cuba.

2.2 Effects of Increase in Price of Oil

Beginning from the immediate years following the initial increase in the price of oil, LDCs have found themselves in the throes of a virulent and excessive inflation and had to face a decelaration in their economic growth rate and a massive deficit in their balance of payment.[19] On the other hand, OPEC's surplus - which corresponds to every dollar of importing countries' deficit - has gone over $350 billion by June 1981. Such huge surplus - roughly twice the economy of Britain- is according to the Economist, "the largest transfer of resources in world history."[20] Though high import bills are a head-ache to all oil importing countries, its adverse effect is nowhere as damaging as it is to economies of LDCs. A good indication is the consequent horrifying debt these countries have plunged into. The external debt of LDCs increased from "87 billion to US $524 billion in the decade to the end of 81"[21] and is estimated to be more than double their annual export.

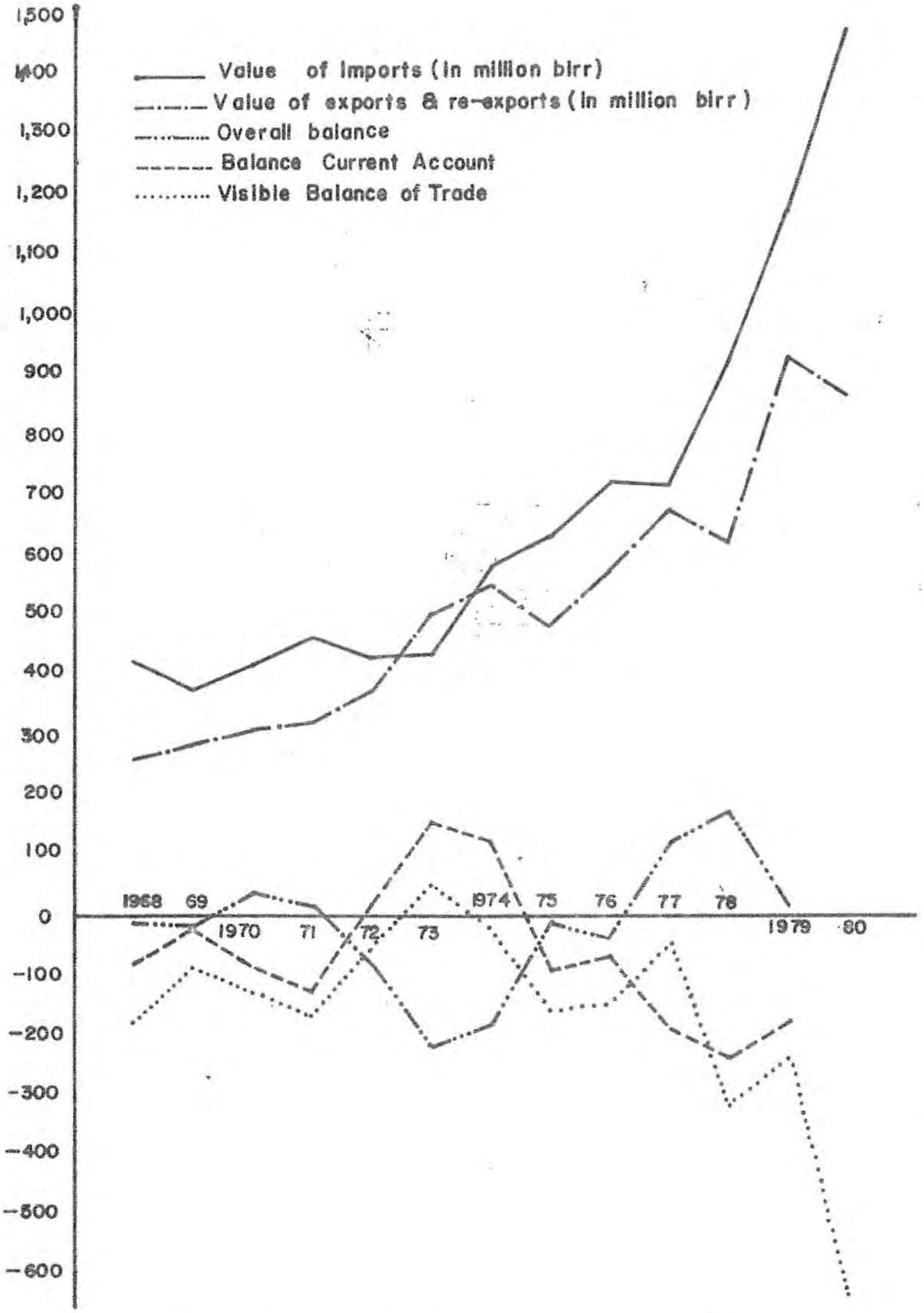
In what follows we will try to examine the effect of such price rise in Ethiopian economy.

2.2.1 Effects on the Balance of Payment

Deficit in Ethiopia's balance of payment has been so frequent over the years to have become a basic feature of the foreign trade sector.[22] The deficit experienced since the 1973-74 increase in oil price is however, widening at an alarming rate. Real balance of trade deficit has almost quadrupled since the oil price rise.[23] The mean balance of trade in real terms (1964 EC price) for 1958-66 EC was 101.4 million birr. This figure increased to 221.2 million birr for the period after the oil price increase (1967 - 1972 EC). Undoubtedly, some of the internal factors discussed earlier have contributed to the worsening of the situation. The main determinants are however to be found in international market, mainly in the world prices for imports and exports of which rising cost of crude oil is the most important factor.

Domestic demand for CE exerts pressure on Ethiopia's balance of payments in different ways amongst which : a) import of petroleum and derivatives, b) purchase of equipments and other capital goods for operating the sources of energy and supplying overall demand, c) payment for technical services are the major ones. Of the three it is the former that is dominant. The share that import of crude oil claims from export earning has increased from a mere 6.7% prior to 1973-74 to 34% in 1980.[24] Alarming as the above figure is, it does not give us the whole picture since it excludes many other factors. Not only does it not include the value of some imported petroleum products whose price has increased but also the accelerated growth

Figure 2.2.0 Balance of Payments: Graphical Representation 1968—1980



Source: Data Compiled from NBE Quarterly Bulletins in the prices of manufactured goods.

Higher prices of oil contribute to cost push elements of inflation, and as a result the industrialized countries simply increase the price of their outputs. The burden of increase in oil price is thus pushed onto oil importing LDCs like Ethiopia who have to bear the double brunt of the "energy crisis". As Table 2.2.0 indicates the import items are so essential that any decrease in quantity of import would either hamper economic development (chemical, industrial products, transport, etc.), or adversely affect the welfare of the population (medical and pharmaceutical goods, food items, etc.). The demand for imports thus being price inelasitc do not give much room for alleviating the problem from the import side.
To add insult to injury, the trade and payment position of LDCs is also further aggravated by adverse effects on the export side. Since export volume of these countries is heavily conditioned by the extent of real demand in the developed countries, coupled with the fact that price of primary commodities is extremely sensitive to demand conditions, many primary goods exporting countries are facing sagging demand and falling price for their export commodities as a result of economic recession currently affecting the develped countries. The current downward trend in price of coffee on the world market is quite an indication.[25]

What renders the condition still worse is the country's export structure. In contrast to the diverse import structure presented Ethiopia provides a classic case of monoculture economy. While agricultural exports have always constituted the bulk of its total exports (over 95%) the share of coffee in total exports has continued to increase, accounting for almost 75% of total exports in 1978/79. Of the remaining 25% hides and skin accounted for 15% leaving a mere 10% for the rest.[26] The instability that such strong dependence on one or two commodities entails is obvious and need not detain us here.

Table 2.2.0 _ Principal Imports (in '000 birr)

ITEMS	YEAR (E.C)								
	1963	1964	1965	1966	1967	1968	1969	1970	1971
Chemicals	28148 (11.1)	21381 (7.9)	26357 (10.6)	41345 (14.0)	60127 (16.0)	45822 (11.7)	48372 (11.3)	37581 (8.2)	98015 (12.5)
Fuel	41196 (16.3)	48970 (17.9)	47936 (19.3)	89251 (30.3)	140860 (37.6)	114825 (29.1)	107948 (25.3)	127633 (27.7)	158511 (20.1)
Transport	39820 (15.7)	50760 (18.6)	48651 (19.6)	45288 (15.4)	51741 (13.8)	106312 (27.1)	92118 (21.6)	83040 (18.0)	181088 (23.0)
Industrial	92430 (36.5)	110038 (40.3)	89245 (35.9)	66941 (22.7)	25815 (6.9)	52833 (13.5)	109984 (25.7)	142359 (30.9)	229026 (29.1)
Medical & Pharma-ceuticals	14231 (5.6)	12531 (4.6)	12193 (4.9)	15199 (5.2)	18935 (5.1)	21674 (5.5)	29446 (6.9)	32329 (7.0)	50641 (6.4)
Food Items	37453 (14.8)	29299 (10.7)	24121 (9.7)	36385 (12.4)	77396 (20.6)	51186 (13.1)	39423 (9.2)	37695 (8.2)	69879 (8.9)
Total	253278 (100)	272979 (100)	248503 (100)	294409 (100)	374874 (100)	392652 (100)	427291 (100)	460637 (100)	787160 (100)

- Figures in brackets, below the values of the import items are percentage shares.

Source: NBE Quarterly Bulletin, Vol. 2, 1980, p. 101.

Regression of real imports (M) and exports (X) on GDP was made (1958 - 1972 EC), and according to the projections made based on the result, the real balance of trade deficit in 1978 and 1983 E.C. will be 251.6 and 335.3 million birr in constant 1964 E.C. prices - assuming a GDP growth rate of 5.3% per annum.[27]

$$M = -17.79 + \underset{(0.013)}{0.12}\ GDP \quad \ldots\ldots \quad 2.2a$$

$$R^2 = 0.86$$

$$X = 14.65 + \underset{(0.009)}{0.08}\ GDP \quad \ldots\ldots \quad 2.2b$$

$$R^2 = 0.86$$

*Coefficients are significant at 1% level.

The severe strain that such chronic deficit puts on the economy is quite evident. Moreover, while the 12% marginal propensity of import could very well be assumed to increase (given the country's plan to increase the contribution of industry to GDP - from the present 16% to 25% by 1990),[28] the same could not be said confidently regarding export.

Deficit could not of course continue indefinetly and need to be covered. This would lead to the inevitable use of foreign exchange reserve. Ethiopia's foreign exchange reserve has gone down to 122.7 million birr in 1980, from a high level of 618.7 million at the close of 1975.[29] Theoretically, borrowing is one possible way of stabilizing the economy under such conditions. Unfortunately the high cost of borrowing in the international market does not allow such a possibility. Already as a result of such high interest rates the debt servicing ratio of LDCs "has increased from 14% in 1973 to 21% in 1981."[30]

Thus, lack of a viable alternative is already necessitating painful choices with respect to imports leading in some cases to reductions on imports of essential supplies, and worse still making financing of urgently required capital goods very difficult. Needless to say, the reduction of such essential inputs would inevitably suffocate economic growth, which in turn will lead to the limitation of the country's foreign exchange earning capacity. The consequence of such circular causation of negative factors is not difficult to imagine.

2.2.2 Effects on Economic Growth Rate

The effect that the reduction of imports of capital goods could have on economic growth rate would not generally be immediate. The strain brought about by the energy crisis was however strong enough to cause a more than 50% decline in the average economic growth rate of oil importing countries in the first three years of the price increase.[31] Now that the price has even increased further (from $14 per barrel in 1977 when the study of Leigh et. al. was made, to $34 per barrel in 1981), the situation must have worsened.

Ethiopia's GDP/cap growth rate started to decline beginning from early 60's. (See table 2.2.1) But it was only after 1966 EC. that it started to show a negative growth rate. The mean value of annual growth rate for 1958-1966 EC was 1.96%. This figure declined to -0.35% for 1966-1973. One would immediately surmise the oil price increase to be the cause in line with the conclusion arrived at by Leigh et. al. Closer look however reveals a more profound factor behind such a drastic fall in the growth rate. As was discussed in the foregoing pages, a host of internal factors had adversely been affecting the economy. These factors could have equally contributed to this effect. The fact that the growth rate went negative for the five immediate years following the revolution and then started to show a sharp rise with the coming of relative stability - despite the continued rise in the price of oil well into 1979 - infact suggests the internal factors as being more decisive, though the oil price increase has undeniably exerted a no small influence in the same direction.

Table 2.2.1 Average growth rate of GDP/cap growth rate

Period (E.C)	Average grwoth rate of GDP/cap
58 - 62	2.24
62 - 66	1.02
66 - 70	-2.13
70 - 73	2.15

Source: Compiled from data from C.S.O., CPSC.

Inorder to see whether empirical results corroborate the above hypothesis, regression analysis was made. The aim was to see if growth rate in GDP/cap was to any significant degree affected by rates of oil consumption, investment, etc.[32] Accordingly, growth rate of GDP/cap was regressed on growth rates of CEC/cap, GDI/cap, LFC/cap as well as on total LFC, energy intensity respectively.[33] In all cases, no statistically significant relationship was found. Regression using other dependant variables (growth rate in Agr/cap, Ind/cap, etc.) also obtained similar results. This we feel is a further indication of the fact that though important, the oil price increase was over-shadowed by other more acute and decisive factors. These we take them to be the largely non-economical factors described earlier.

Nonetheless, such a conclusion must not be allowed to undermine the debilitating effect that high cost of fuel had or could have, especially now that the foreign exchange problem is getting more serious (with the depletion of our reserve) and the decline in price of our major export commodity - coffee. We hold that the decelerating effect of the oil price increase would have been reflected in our result (similar to that of Leigh et. al.) had it not been for the non-economic factors which hurled the economy into negative growth rates.

2.2.3 Effects on Inflation Rate

Inflation has to day become a global phenomenon affecting the economy of developed and developing countries alike. As a result controlling inflation has become the main concern of the decade. As would be expected those who suffer most from its effect are LDCs whose average inflation rate more than tripled, from 7.7 to 24.9% in the first three years of oil price increase and strongly appear to have been caused by it.[34]

As can be seen from table 2.2.2 below, in the first eight years prior to the price increase in 1966 E.C. the standard of living as indicated by the general price index (Px) shows one of mild inflationary tendencies, essentially of a cyclical character, with some years showing negative percentage change over the previous year.

Pre and Post 1966 E.C Values

Table 2.2.2

Year E.C	General Price Index (Px)	Percentage Change	Import Unit Values	World Price Index of Crude Oil	Year E.C	General Price Index (Px)	Peoentage Change	Import Unit Values	World Price Index of Crude Oil
1958	92.4	-	87.3	79.0	1966	111.7	10.7	112.1	326.0
1959	92.1	-0.32	89.9	79.0	1967	117.[illegible]	4.7	120.3	499.9
1960	92.6	0.54	91.9	79.0	1968	139.[illegible]	18.8	126.8	499.9
1961	93.3	0.76	93.9	79.0	1969	154.7	11.3	135.3	552.5
1962	99.3	6.43	94.1	79.[illegible]	1970	180.3	16.6	148.3	595.5
1963	105.3	6.04	96.7	79.[illegible]	1971	227.9	26.4	162.8	782.4
1964	100.0	-5.03	100.0	100.0	1972	255.5	12.1	176.6	1269.3
1965	100.9	9.00	104.1	100.0	1973	-	-	-	-

Sources: CSO; IMF, "International Financial Statistics", 1980; NBE Quarterly respectively.

With the advent of the "oil crisis" however, prices of all goods have moved in tandem with oil prices, and as a result the earlier modest inflation rate all of a sudden jumps to an unprecedented level of 10.7% (almost 12 times that of 1964 E.C. and more than 20 times the rate of five years earlier) and continued to increase reaching the highest level of 26.4 in 1971 E.C.

In the belief that the major determinants for this sudden turn are the series of price increase of oil (19 times compared to its price a decade earlier - see table 2.2.2) we have attempted to see the extent to which it has led to increase in domestic prices. We have chosen two variables - GDP deflator (Pf) and General Price Index (Px) as indicators of the inflation rate. These two were separately regressed on whole sale price index of petroleum (Pw).

$$P_{ft} = \beta_0 + \beta_1 P_{wt} + \mu \quad \ldots\ldots \quad 2.2c$$

$$P_{xt} = \beta_0 + \beta_1 P_{wt} + \mu \quad \ldots\ldots \quad 2.2d$$

The analysis was made in three stages. First, regression was made for all observations 1958 - 1973 E.C.[35] The observations were then divided into two groups - pre and post price increase of oil. Table 2.2.3 summarizes the results obtained.

The results obtained indicate the existence of strong and positive relationship between the variables for the post price increase period (observations 8 - 16) while no such statistically significant relationship was found for the pre-price increase period.[36] Though not conclusive, the result is highly suggestive of the influence of oil price increase on the country's inflation rate.

Inflation Rate Regression Results

Table 2.2.3

Observations	Dependent Variable	Independent Variable	Intercept $\hat{\beta}_0$	Coefficient $\hat{\beta}_1$	Standard Error of $\hat{\beta}_1$	R^2
1 - 16	P_{ft}	P_{wt}	90.26	0.107*	0.015	0.78
	P_{xt}	P_{wt}	62.15	0.332*	0.045	0.80
1 - 8	P_{ft}	P_{wt}	96.64	0.023	0.027	0.11
	P_{xt}	P_{wt}	93.32	0.033	0.032	0.15
8 - 16	P_{ft}	P_{wt}	96.00	0.093**	0.034	0.52
	P_{xt}	P_{wt}	39.93	0.387*	0.101	0.68

P_{ft}= GDP deflator

P_{xt}= General Price Index

P_{wt}= Whole Sale Price Index of Petroleum and derivatives.

* Significant at the 1% level.

** Significant at the 5% level.

Higher prices of oil contribute to cost push elements to inflation, and as a result the industrialized countries simply increase the price of their outputs. For instance, the 150% oil price rise from January 1979 to January 1981, according to Time Magazine "sent American consumer prices leaping at an annual rate of more than 12%, the steepest peacetime increase in more than 30 years."[37] Thus higher import prices stemming from such inflation in the industrialized countries (see the more than 100% unit price increase of imports in table 2.2.2) have undoubtedly aggravated domestic price situation. Table 2.2.3 also is indicative of the extent to which price increase of imported goods could have contributed to this end.

Import Volume and Value for Vehicles and Industrial Machinery

Table 2.2.3

Import of Vehicles			Import of Industrial Machinery	
Relatives: 1974 = 100			1974 = 100	
Year	Volume	Value	Volume	Value
1974	100.0	100.0	100.0	100.0
1975	93.0	121.0	80.7	100.4
1976	104.7	148.3	75.7	105.5
1977	134.9	153.8	62.9	110.3
1978	143.0	274.3	101.4	195.6
1979	81.4	119.3	112.9	242.8
1980	123.3	268.5	123.6	286.0

Source: Customs Authority; NBE.

Higher fuel costs have equally contributed to cost push inflation at home. Since CE consumed largely goes to productive processes, rather than being directly consumed, we hold that much of the increase in energy cost will eventually be transferred to higher output prices.

Inspite of such strong indications, it would be presumptous to hold the oil price increase as the only cause for the accelerated rate of inflation. Domestic factors have also exerted significant influence in the same direction. In the face of supply shortage due to disruption of economic activities (for reasons cited earlier), government policy remained expansionary. Increase in the money supply (an increase of 121.8% from 1973-79 as compared to 63.7% between 1963-73)[38] and government expenditure (an increase of 204% between 1973/74 - 1973/80 as compared to 49% from 1967/8 - 1973/74)[39] have also contributed to the inflationary trend. Sectoral bottlenecks and different problems associated with distribution can similarly be cited.

While some of the domestic causes for the inflationary pressure have abated, external factors (though not in the same rate) still continue to influence price increase. Infact, a very important feature of this post 66 E.C. exceptional upsurge in inflation rates is the fact that it is basically imported cost inflation over which we have very little influence or control.

3.0 Supply and Demand for Commercial Energy.

Commercial energy constitutes a mere 4% of the country's total energy consumption. Out of this hydro-power accounts for about 7% while petroleum accounts for the rest. (see Table 3.1.0). Though currently of small significance, hydro-electicity is foremost among the energy sources that offer promising prospects and it is towards the discussion of this source of energy that we now turn.

3.1 Electricity : Supply Problem and Prospects

Being a renewable source of energy, hydro-power offers the most promissing source of electric energy for countries like Ethiopia endowed with substantial potential source. Currently, however, out of a potential of 60 billion KWH, the production capacity of existing plants is only 1.044 billion KWH or 1.74 percent.[1] Such insignificant contribution of hydroelctricity to the country's overall energy consumption and the enormous dependence on imported oil is reason for serious concern. At present, hydropower contributes a mere 0.33% of total energy consumption. Over the years the share of hydropower in the country's installed generating capacity and production has (on the average) been around 73% and 76% respectively. The remaining (27% of capacity and 24% of production) is left to thermal production[2].

The disadvantage of diesel units is one that deserves serious consideration from both the economic and energy point of view. Costly generation interms of calories is a serious drain on physical and financial resources and very often on foreign exchange. Diesel units have low thermal efficiency. "The motors operating at high rotational speeds of 1000 or 1500 rev/min (involve) high maintainance costs, long outage periods and relatively short life span"[3] as compared to hydro-electricity. The latter involves no fuel cost requires few operations, has low maintainance costs, and an efficiency rate of about 95%.[4]

Despite such advantages, our potential remains unexploited, leaving us saddled with the energy problem. Such relatively high share of thermal production is generally explained by the preference held for thermal installations based on the lower initial cost, the possibility of installing them quickly and reaching consumers that are small in number and far from main centers. The low price of petroleum in the past also made it attractive in terms of cost.

Even then, one cannot rule out lack of perspective planning and foresight on the part of policy makers. Strategic considerations alone can be reason enough to follow a policy of developing one's own resource inspite of the initial cost involved.[5] After noting the extent to which hydroelectricity contributes to a country's energy self-sufficiency and significantly improves food security and balance of payment position etc, an E.C.A. report of experts goes on to remark that such "strategic importance in itself could justify investments which would not be immediately profitable from a conventional point of view.[6]

It is interesting to note that many countries of the East and West (USSR, USA, etc) have developed their hydro potential, their substantial petroleum resources notwithstanding. Some African countries too have been able to exploit a relatively large amount of their hydro potential. For instance, though Ethiopia ranks 9th along with Mozambique and Uganda, in hydro potential, it stands 16th in the amount of hydro-electricity produced.[7]

Estimates of annual (1976) energy derived from various sources for overall end-use categories:

Peta joules[1] and percent of total annual consumption

Table 3.10

Energy Source			Non-Commercial Form: Wood, Charcoal Dung and crop wastes [2]	Non-Commercial Form: Plough Oxen [3]	Non-Commercial Form: Pack animals [3]	Commercial Forms: Oil fuels	Commercial Forms: Electricity	Totals
Overall end use category								
Domestic and Commercial including Rural	Principal for cooking and heating	PJ	575.0	--	-	0.2	0.5	575.7
		(%)	(94.76)	-	-	(0.03)	(0.08)	(94.87)
	Rural Transport	PJ	-	4.3	1.8	-	-	6.1
		(%)	-	(0.71)	(0.30)	-	-	(1.01)
Formal Industry and Motorized	Vehicular Transport	PJ	-	-	-	13.2	-	13.2
		%	-	-	-	(2.18)	-	2.18
	Industry	PJ	-	-	-	4.4	1.2	5.6
		%				0.72)	(0.20)	(0.92)
	Other includings oils used for electricity Production	PJ	-	-	-			
		(%)	-	-	-			
Totals		PJ (%)	575.0 (94.76)	4.3 (0.71)	1.8 (0.30)	23.7 (3.90)	2.0 (0.33)	606.8 (100.00)

Notes: 1. Conversion Factors: 1 petajoule (PJ) = 34120 tonnes coal (23880 tones oil); million tonnes coal = 29.18PJ.

2. Total biomass use is taken as 31,000,000 tonnes (1 tonne /person/year)

3. Animal power estimates are derivedfrom estimated animal numbers in Ethiopia and average work output /animal/

N.B. Figures are only indicative approximations are revised.

Source: Beijir Institute, p. 8

Furthermore, countries like Egypt, Zambia, Zimbabwe, Senegal produce, 25, 23, 9 and 7 times Ethiopia's production level (respectively), despite the fact their potential is on the average that of Ethiopia. This is an ugly reminder of the extent to which we neglected the exploitation of our resource, when capital cost was relatively much cheaper. It is also an indication of backwardness since electricity development which constitutes an advanced stage of energy utilization, is generally regarded as a prerequisite for economic and social progress (Industrial development, mechanization and urban development are strongly related to electricity consumption). Moreover, in the turmoil of the present " crisis of energy", these countries would be in a better position to stand the shock th n countries like Ethiopia, which depend totally on imported petroleum.

The bulk of Ethiopia's electricity production is provided by E.E.L.P.A. Of the 523 million KWH of total generation during 1968 E.C. E.E.L.P.A. produced 88.3%. the Assab oil refinery and the sugar estates making up for the rest. In 1979, E.E.L.P.A.'s installed generating capacity (excluding 2.5 MVA from the Assab plant) was 306.81 MVA.[8]

Apart from areas that get electricity service from the main installations like Fincha, Awash I, II and III (interconnected system), there are less than six towns (excluding Bahr Dar) that have hydroelectricity with installed capacity ranging from 184 to 100 KW. Moreover, virtually all of the stations use diesel generators in addition to hydropower.[9] Thus, of the power stations within the self-contained system (SCS), over 90% of them are thermal stations.

The average growth rate of installed generating capacity from 1960-65 (E.C.) was 14.6 percent, while the corresponding figure for 1965-1970 (E.C.) was 0.51 percent. In view of the large capital outlay that electric production requires and the small(and declining) share of gross annual investment that the sector has absorbed over the years, supply shortage in years to come seems imminent.

Capital formation in Electricity and Water

Table 3.1.1.

Year E.C.	1963	1964	1965	1966	1967	1968	1969
Gross Fixed Capital Formation On Electricity and Water	46.5	42.8	19.9	11.4	15.9	17.8	14.3
Percentage share in Gross Fixed Capital formation	9.3	8.6	4.3	2.3	3.4	4.5	3.2

Source CSO, Statisticsl Abstract 1976, p. 138 and 1978 p. 144

To be complancent with a small margin of reserve is very misleading and eventually dangerous. Increased demand will quickly exhaust the existing surplus and the long gestation period involved to install new hydropower will make increased supply impossible in the short run. In the meantime, one would be forced to suffer shortage of supply in the face of increasing demand. If the present yearly load keeps increasing 7% the country could very well face an acute electrical energy shortage in 1983-1984[10]. One can cite a number of cases from other countries (India, Nigeria etc.) Where the supply of energy had lagged behind demand thereby prejudicing the national economy.

The present capacity of E.E.L.P.A. and the long lead time of power projects makes one apprehensive of similar problems to occur here as well, especially when one considers the energy requirements of industries planned to be established in the near future and the plan to raise the countribution of industry to GDP from the present 16% to 25% by 1990[11]. Whether the supply could increase to meet such demand of course remains to be seen. What is clear though is the fact that, given the country's committment to bring about industrialization, failure of supply to meet demand could lead to wasteful utilization of resources. If faced with such a dilemma, either shortage has to be tolerated with the far reaching implication on industrial expansion and other productive sectors or face the equally wasteful alternative of establishing thermal power stations inorder to respond quickly to increased demand. Worse still, the building of such stations would soon turn to be a complete waste since installation of hydroelectric powers would immediately make it marginal.[12]

Consumption of electricity from the start was dominated by the industrial sector which accounted for 60% in 1972. Though this figure has declined a little bit, (55% e.g. for 1979), non industrial consumption still represents less than half[13]. Electric production is largely used for production purposes (see table 3.1.2). Even such consumption given under domestic and commercial could also include productive activities in the sense that cottage industry type activities are usually done at home. and there is no way of telling exactly the part used for direct consumption from that used for productive ends.

The problem regarding the consumption pattern is, therefore, not so much diverting present electric consumption to more productive use (though to some extent this is true), as to substitute hydro-

Estimated 1976 Consumption of Energy by Sector

Table 3.1.2

	Commercial Energy			Non Commercial Energy		Total Energy Consumed	
	Fuel MM Tons	Electricity GWH	Total in ce MM tons	Total in MM tons	Total in ce MM tons	in ce MM tons	in Kg ce Per caput
Industrial	0.096 (18.9)	324 (59.1)	0.186 (21.5)	-	-	0.186 (0.9)	6.5 (0.9)
Transport	0.280 (55.0)	-	0.451 (52.1)	-	-	0.451 (2.2)	15.8 (2.2)
Residential & Commercial	0.004 (0.8)	150 (27.4)	0.026 (3.0)	31.0 (100)	19.6 (100)	19.626 (95.9)	686.2 (95.9)
Others uses (including fuel for electricity production)	0.129 25.3	74 (13.5)	0.203 (23.4)	-	-	0.203 (1.0)	7.0 (1.0)
Total	0.509 (100)	548 (100)	0.866 (100)	31.0 (100)	19.6 (100)	20.465 (100)	715.5 (100)

1. In the total for Commercial Energy 0.054 MM tons of fuel used for for electricity production had not been deducted.
2. Non- Commercial Energy(Wood, Charcoal, dung and crop-wasts) has been assumed to be mainly for Residential & Commercial use.
3. MM tons = Million Metric Tons
4. ce Coal equivalent
5. Figures in brackets are percentages.

Source: ENEC

electricity for petroleum based energy sources.

Not withstanding the enormous need and advantage of hydropower, a point of qualification is in order. T he huge amount of capital cost required to establish such installation is one hurdle that militates, against rapid utilization of existing potential. The existence of such resources further removed from big consumer centers makes it even more problematic, since the high transmission cost involved often becomes almost insurmountable. It is in fact estimated that for every dollar invested in the construction of hydroelectric station, the corresponding cost for transport and distribution network and expenditure on purchase of machinery to use the energy would be US$1.50 and $5 respectively.[14]

Even then, hydropower is the best (and given our present knowledge of the country's energy resources), the only alternative inspite of the high cost of investment it involves.

Various areas have so far been found to be suitable for hydropower generation. Areas that have been investigated include the Blue Nile basin where most of the country's potential is concentrated. The basin includes the Fincha river on which the country's largest hydro-electric plant with installed capacity of 100 MW and average annual production capacity of 532 GWH is installed. From its source at lake Tana to the border with the Sudan, the river Abbay runs for about 600 miles, over an area believed to provide for a vast irrigation project. Starting at an elevation of 1,786 meters and falling to its lowest level of 486 meters near the border, the Nile basin "covers about 200,000 sq. kms, and the river within Ethiopia has a theoretical power potential of 172 billion KWH/year of which 38 billion KWH/ year could be technically developed", i.e if seen interms of capacity about, 22.8 times Ethiopia's present power capacity[15].

Such enormous capacity of the Blue Nile basin if fully exploited can meet local demand of electricity for the year 2000[16].

Other major areas are the Wabi Shebelle, Tacaze, Omo and Awash, the latter being the site of Awash I, II and III with a combined installed capacity (in 1977/78) of 107200 (KW) and production capacity of 210,220,000 KWH. The Awash basin also constitutes an area with extensive irrigation network and a number of modern farm projects.

The Wabi Shebelle, though currently underutilized covers an area with enormous economic importance for the country. Extending from Arsi to the Ethio-Somali border, the Wabi Shebelle basin is reported to have sharp climatic differences, a drainage area of about 200,000 square kilometers and the largest flood plain of all the river basins in the country; a power potential of 9 billion KWH/year which could help to cultivate 200,000 hecaters[17].

While the above constitute the major potential areas, there are a number of small rivers suitable for small scale hydroelectric plants. Their potential in terms of rural electrification is of very great significance. In fact from the view point of planned development it is the exploitation of these economically attractive small scale hydro power sources that should get priority attention from LDC's. Small hydropower plants can utilize small heads of water to supply significant amounts of electricity for irrigation, potable water pumping, lighting, or for health and educational purposes in rural areas- a scheme which would otherwise be impossible or very costly. It is reported that in China for instance,extensive use of such small rivers is made of to supply power for small scale local industries, irrigation, threshing and milling, fodder curshing, timber sawing, etc.. Although the potential amount of such rivers in Ethiopia is not well documented, given the Ethiopian topography and amount of rainfall one can safely assume it to be quite large with wide area of coverage.

The cost of such small-scale hydroelectric installations is known to vary widely, but is believed to be competetive enough, and with rising oil prices more advantageous than thermal power. Furthermore it is evident that the present cost will decrease as the technology develops making it economically more attractive.

Another approach which is expendient and offers better prospects in rural electrification programmes is the possible use of capacitors instead of transformers to tap the grid. Admittedly the issue is very complex, expecially for countries like Ethiopia with very limited technical and manpower resources, but it should also be known that it is the only way of achieving integrated rural development.

> "Whether in the field of the modernization of agriculture, the development of land through irrigation, the treatment and conservation of agricultural and other products the extraction of raw materials and their processing, the exploitation of forest resources, the transport of agricultural or manufactured products or the search for an increase in social facilities, in every case electricity responds with greater felxibility than the competing forms of energy to the imperatives of development in our countries and of the transformation of rural economies".[18]

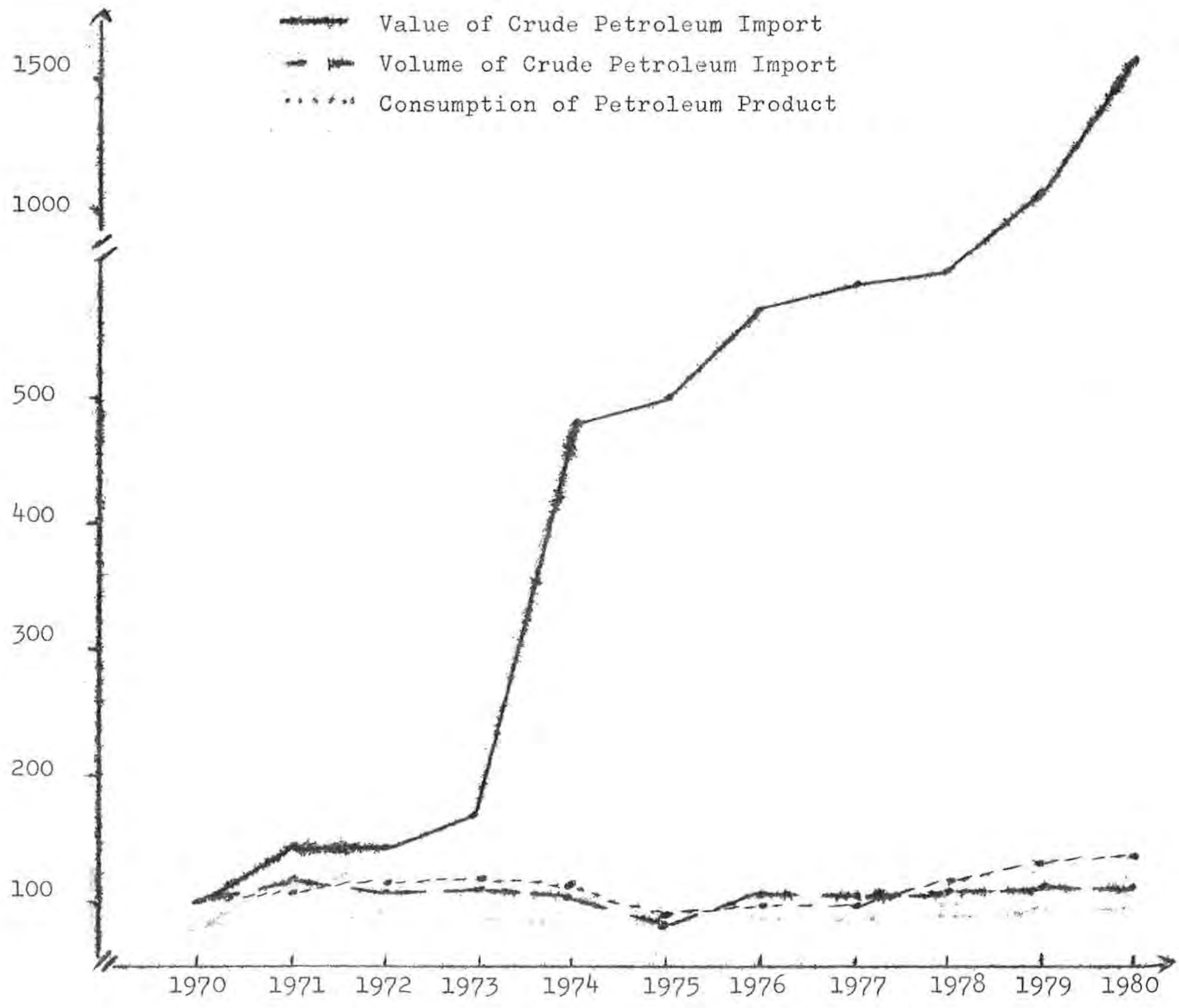
In general hydroelectricity is the power source on which the development of our country should increasingly depend in the future. That is why longterm planning of electricity supply should get priority attention. Moreover, such supply planning of eclectricity shouldn't be undertaken in isolation from the longterm planning of economic activities by sectors and areas of development for otherwise it wouldn't be possible to provide the required amount at the time and place of interest.

3.2. PETROLEUM

The relatively cheaper price and high flexibility of petroleum in its use has like so many other countries lead Ethiopia to neglect the need to diversify commercial energy sources and to fall into compelete dependence. As a result today petroleum accounts for 92-93% of total CEC.

The sudden quadrupling of oil prices has brough to light the debilitating effect of such strong dependence on external power source. Even though the quantity of crude petroleum imported has not changed much over the years, the country at present pays over 300 million compared to 20 million birr ten years ago.

Figure 3.1.0 Value, Volume & Consumption of Petroleum, 1970-1980



As can be seen from the figure above value of crude oil import in 1980 increased by 1449 while quantity of import increased by a mere 11% on the 1970 level.

Consumption of petroleum products has shown an erratic trend over the past years. As figure 3.1.0 clearly shows a relative decline in consumption is seen to start immediately after the 1973/74 price rise. This trend continues to 1975 where consumption infact goes below the base year level. The 1973 level is reached, only after 1978 from whence onwards we see a sharp rise.

It is difficult to isolate and measure the magnitude of factors that lie behind such a trend in consumption. The dominant role of the war is not however difficult to see, in view of the great inertia experienced in CEC which prevents an adequate adjustment to rapid changes in prices. The sharp fall in CEC can to a large extent be taken to indicate the effect of the abnormal condition. The consumption pattern of the northern region is a clear indication. Not only did the share of petroleum in the Northern Region decline more than the rest during the war, but it also started to catch up rapidly with the coming of political stability to the region and the resumption of economic activity particularly that of industrial activity.[18] The fact that fuel oil which is mainly used by industries and bunkers declined during the period mentioned and started to rise soon after is another indication[20].

Table 3.1.3

Period (E.C.)	Average Growth Rate of Consumption of Liquid Fuel Consumption/Cap.
60-63	9.2
63-66	4.5
66-69	-5.0
69-72	9.5

Source: Compiled from EPC data for Petroleum

As can be seen from the table above (Tabel 3.1.3) after the decline experienced between 1966-69 E.C., consumption starts to increase at a much higher rate ranging from 8 to 17% annual growth rate mainly as a result of reconstruction effort and the resumption of economic activities closed down earlier and partly due to increase in demand resulting from expansion of the economy. Whereas the former may gradually wear off as it reaches previous levels, it is the latter aspect that interests us, since it is the rate of growth of the economy which will be affected by the rate of growth of oil prices.

3.2.1. Refinery and Distribution Costs.

Since in the case of petroleum, refinery and distribution costs are important factors on the cost of energy products which reaches the end consumer, cost minimization to lessen the magnitude of average price that the consumer is required to pay is one very important way of combating the problem from this end. It would be very unwise to view efforts at reducing operating costs as marginal and hence not worth the effort.

Refinery and Distribution

About 95% of the petroleum products consumed in the country is refined at Assab. The 5% or so of refined petroleum import constitutes mainly of lubricants and aviation fuels.

The Assab oil refinery started its operation in 1967. It was constructed by the Soviet Government in accordance with the credit they extended to the Ethiopian Government. The initial capital for construction was 44million birr. The operation began with an additional capital setup of 54 million birr. It was initially designed for 500,000 ton/year processing capacity. As a result of action taken by the EPC to upgrade its capacity a 650,000 ton/year capacity was reached by the third year of operation. Similar modifications were done in the past few years raising the capacity to a record level of 800,000 tons, per year. Despite the commendable effort by the corporation this capacity (16,000 barrels per day) is small even when compared with that of some developing countries like Ethiopia.[21] Whereas the large complex refineries in the industrialized countries have a capacity ranging from 100,000 to 600,000 barrels per day, that of LDC's is within the range of 20,000 to 50,000 barrels a day.[22]

Given the essential link of refineries in converting crude oil to the various petroleum products needed by consumers, it is not difficult to appreciate the importance of a refinery to the country. But like all imported technology from the advanced countries, refineries too pose a problem of fitting into the economic needs of LDC's .

One problem is the fact that combination of products produced are not all required for domestic consumption. Since the industrial base for countries like Ethiopia is small, a substantial amount of heavy oil such as fuel oil has to be reexported. The price obtained for such re-exported would not in many cases be competetive. There are infact reports that in many cases it is sold at "distress prices".[23] The present tendency of many countries (including Ethiopia) to replace fuel oil by hydro-power further reduces the demand aggravating the re-export price. However, the move taken by some countries to install cracking facilities (a move considered not feasible in Ethiopia) to convert heavier fuel such as fuel oil into lighter ones such as gasoline, acts as a countervailing force. The future price of fuel oil of course depends on the extent of development of the two trends in and around Ethiopia.

Production -Yield Statement (Crude Oil) (2nd Quarter 1980

Table 3.2.0

Product	Quantity (MT)	% WT
LPG	1,006	0.79
Gasoline (regular)	14,965	11.77
Gasoline (premium)	661	0.52
Light Jet Fuel	6,804	4.88
Gasoil	29,721	23.37
Marine Diesel	1,489	1.17
Kerosene	27	0.02
Inland fuel oil	21,772	17.12
Export and Bunker fuel oil	35,641	28.04
Asphalt	2,698	2.12
Total	114,184	-

Source: EPC

Small scale operation has also a serious drawback since it leads to the loss of economies of scale that would otherwise have reduced operating costs. The operating cost in 1980 US dollars per barrel of throughput for LDC's and world scale refinery was estimated to be 4.5 and 2.1 respectively[24]. Thus, although crude oil is cheaper than importing its derivatives, the advantage of establishing refineries is countingent upon the volume and structure of consumption. Limited domestic market and structure of consumption that doesn't conincide with the combination of products produced will make external market necessary. The alternative in many cases is either using very low production capacity which leads to very high cost of operation or big refineries which operate below capacity, both of which lead to very high cost and inefficiency.

Internal Distribution

Internal petroleum productsmarketing has also a great bearing on the final price. Since the relatively small consumption of petroleum was thought not to warrant such facilities like oil and gas pipeline, almost all of the internal distribution is done by rail and road transport the latter accounting for the lions share.

An efficient transport network figures very important in every line of production. This is even more true for the hydrocarbon industry whose complexity requires a series of interdependent services from the stage of extraction until it reaches the final consumer. First the crude oil is shipped from the source of supply by oil tankers to the port[26]. The refined products are then distributed to the final consumers mainly by means of tankers. The cost of transporting the refined products of course varies depending on the distance, mode of transport and quantity transported.[27]

The need for large storage facilities at the various intermediate levels is of course a salient point . Apart from making distribution stable and efficient, storage facilities enable the efficient utilization of the transport system especially in the case of lorries. Pipelines offer the most efficient mode of transport. But the establishment of pipelines requires a threshold consumption level. Oil producing countries like Algeria, Nigeria, Lybia and many countries of North Africa have oil and gas pipelines. Some non-oil producing countries like Kenya and The Sudan have undertaken construction of pipelines for petroleum products (from Mombasa to Niarobi, a distance of 450 kms and from Port Sudan to Khartoum, a distance of 815 Kms respectively.[28] In fact whenever the market in the hinterland seems sufficient (60% of Ethiopia's fuel consumption is in the central region sorrounding Addis Ababa.)[29] the building of refinery nearer to the market and laying of such pipelines to transport the crude oil from the prot will be advantageous, specially in view of the rising cost of petroleum which the lorries (as in the case of Ethiopia) require. Not only is return load impossible with this mode of transport, but it also constitutes an increasing cost coming mainly from the increasing number of lorries required to transport LF to meet increased demand. The congestion that would develop as a consequence and high mainteance cost for both roads and vehicles would entail additional cost making it increasingly uneconomical.

The feasibility of installing a pipeline in Ethiopia was studied over five years ago. Although the study indicated positive returns, to date nothing concrete has been done. As a result of delay in implemntation the cost is reported to have increased faurfold. CPSC is presently reviewing the development of such a pipeline. According to a joint publication by EPC and Neflechimpromenport of the USSR, vaious strategies for development of refinery and pipelines have been suggested of which the first and the one considered economically most beneficial is developing a new inland refinery (to be located in the Majo-Nazreth area) "...without secondary units and connected by a semicrude pipeline to the existing and expanding refinery at Assab... Combined throughput capacity would be 2.6 million tonnes per year "[30]. With a capacity of 1.5 million tonnes per year the 786 kms long pipeline is estimated to cost 590 million birr of which 500 million constitutes the foreign exchange component[31].

Sectoral Consumption

Transport is by far the major consumer of petroleum. In 1979 the figure was 65%, road transport accounting for the bulk of it. Studies made for LDC'S show that more than 85% of the total consumption from transport goes to road transport (cars, trucks,buses) while the rest is for rail, and air transport[32]. In Ethiopia too since rail transport is limited to a length of about 1000 kms (from Addis Ababa- Djibouti, and Massawa-Akordat) and air transport takes less than 1%, roads account for no less than 95% of the sectoral consumption.

Petroleum Consumption by Sectors - 1979

Table 3.2.1.

Sectors	(Percentage share) Light Oils	Heavy Oils	Total
Agriculture	-	6	6
Industry	4	8	12
Transport	60	5	65
Domestic *			0.6
Commercial*			3
Mining *			0.4
Road Construction	3	2	5
Electricity Production	2	4	6
Others*			2
Total	69	31*	100

* Their combined share of heavy oil is 6%

Source: EPC

Industry rates a poor second in the share of petroleum followed by electicity production, agriculture and road construction. Given the rugged topography of the country and the much needed opening of the hinterland, expansion of the industrial base, development of state farms etc. would definitely lead to increased rate of demand for petroleum. The six percent annual growth rate of vehicles reinforces this same conclusion.

Growth Rate and Traffic Composition

Table 3.2.2.

Vehicle type	Annual Growth Rate 1976-1980	Percentage Change of total vehicles in Kms, 1980
All vehicles	6.0	100
Passengers cars	4.5	30
Buses	2.5	16
Small trucks	7.5	8
Medium trucks	7.5	13
Heavy trucks	7.5	15
Tankers and Trailers	9.2	18

Source: Bertlin and Partners, p. 94

In summary: our demand for petroleum is bound to increase (at least in the near future) despite the price increase. Unless all means are employed to reduce cost of refinery and distribution from this end as well as reduce rate of consumption by conservation policy. present consumption would be difficult to finance let alone an increased level. The following section throws light on the extent to which the demand problem would be intensified in the years to come.

3.3. Demand Projections

In what follows, forecasts for CE demand for the periods 1973-78, and 1978-83 E.C. will be made. Both optimistic and pessimistic views will be entertained with respect to GDP growth rates and prices of crude oil. The scenario which we present is "surprise-free" in the sense that it does not entertain any dramatic event (both internal and external) that would have marked effect on future CEC.

Four different possibilities are examined.[33] Two GDP elasticities of demand of CE, 1.5 and 1.3 are used for projection under case 1a. This means a 1% increase in GDP will lead to an increase of 1.5% and 1.3% respectively in CE demand.[34] Case 1b is on the other hand based on the assumption that CE demand will increase at a rate equal to that of population growth rate (2.5%) thus leaving CEC/cap constant over the whole period of projection.[35]

Two GDP growth rates 7.5% and 5.3% are considered.[36] Accordingly, case 1a is calculated as follows.

$$C_t = C_o (1_t r_i)^t \qquad 3(a)$$

Where C_t is CEC in mtce,

t is period of forecast

r_i is growth rate of CE, i = 1,2,3,4, , and

C_o is 969371.42 mtce [37]

Case 2 is based on CPSC's planning target for the coming 10 years, indicative oil consumption[38]. The base year figures are taken from EPC's figures for consumption of petroleum products - 1980-81.[39] Demand growth of 11% for gasoil, fuel oil and LPG, and 7% for gasolines and aviation fuels[40] is used in the build up of the table. Growth rates of 7% and 4% for lubricants and asphalt were employed respectively.[41]

Table 3.3.a Petroleum Demand

in MT

Product	1973	1978	1983
Gasoline	106204	148957	208920
Gasoil	269506	454133	.10560
Kerosene	3719	6267	765241
Fuel oils	88464	149067	251187
LPG	4346	7323	12340
Aviation Fuels	62570	87758	123085
Lubricants	11025	15463	21688
Asphalts	9000	10950	13322
Total	554834	879918	1406343

Source :EPC

Case 3 is based on the result obtained from time series analysis of the following variables.[42]

$$F_t = \beta_0 + \beta_1 Y_t + \beta_2 P_t + \beta_3 L_t + \beta_4 W_t \quad \ldots\ldots (3b)$$

$$F_t = \beta_0 + \beta_1 Y_t + \beta_2 P_t + \beta_3 F_t - 1 \quad \ldots\ldots (3c)$$

$$F_t = \beta_0 + \beta_1 P_t + \beta_2 F_t - 1 \quad 1\ldots\ldots (3d)$$

$$F_t = \beta_0 Y_t \quad \ldots (3e)$$

Where F_t is LFC/cap in Kgce

Y_t is GDP/cap in constant 1964 E.C. birr

P_t is price of crude oil, and

$F_t - 1$ is 1 year lag of LFC/cap

L_t is dummy variable; 0 for the years 1966-70 (considered to be years of abnormal period) and 1 normal period

$W_t = Z_t Y_t$

LFC/Cap regression on GDP/cap and price of crude oil

Table 3.3.1

Model	Dependent Variable	Independent Variable	Intercept β_0	Coefficient $\hat{\beta}_1$	Standard error of $\hat{\beta}_1$	R^2	F Value
		Y_t		0.45*	0.108		
		P_t		0.00024**	0.0001	0.93	34.0
3b	F_t		-52.16				
		Y_t		0.32*	0.108		
3c	F_t	P_t	-34.0	0.00014	0.0001	0.91	39.2
		F_t-1		0.19	0.203		
		$\ln Y_t$		2.70*	0.889		
3d	$\ln F_t$	$\ln P_t$	-11.0	0.02	0.019	0.89	33.5
		$\ln F_t-1$		0.11	0.207		
3e	$\ln F_t$	$\ln Y_t$	-13.44	3.23*	0.319	0.88	102.7

* Significant at 1% level

** Significant at 5% level

As summarized in table 3.3.0. the GDP/cap variable was the only one found to be statistically significant in all cases at the 1% level. The price variable was significant at the 5% level for 3b but fails in the rest. Equations 3b and 3e are chosen for use in the projections.

$$F_t = -52.16 + \underset{(0.108)}{0.45Y_t} + \underset{(0.0001)}{0.00024P_t} \qquad (3b)$$

$$R^2 = 0.93 \; ; \qquad F = 34.02$$

$$\ln F_t = -13.44 + \underset{(0.319)}{3.23 \ln Y_t} \;\ldots\ldots\ldots\ldots\ldots\ldots \quad (3e)$$

$$R^2 = 0.88$$

Closer examination of 3b was necessary before using the price variable for projection. Using the 0.00024 coefficient, price elasticity of LF demand was calculated.

$$\eta_t = \frac{Pt}{Ft} \times 0.00024$$

Where η_t is price elasticity of demand for LF . The range of η_t for the years computed was 0.014 - 0.086 (with an average of 0.034) thus indicating price inelasticity of demand for LF. With virtual absence of substitution for LF and considering its crucial role in productive activities such high degree of price inelasticity is of course to be expected. Generally all productive sectors manifest structural rigidities. The type of technology employed is specific as to the form of energy required and does not give much room for substitution. As a result given the present production structure, demand for LF was bound to be insensitive to the price increases. More on this later.

The positive sign of the price coefficient was counter intuitive (though it too could be an indication of the absence of substitution and the necessity of LF for production)[43].

Case 4 is based on the result of the regression equation made for the low income countries in chapter 2. (see table 2.1.3.)

$$LnCEC/Cap = -2.92 + 1.34 \; Ln \; GNP/cap$$ [44]

Since the equations are on per capita basis, the assumed GDP growth rates are converted to per capita bases as follows:

$$r_y = \frac{r_g - r_p}{1 + r_p}$$

Where ry is GDP/cap growth rate

r_g and r_p are GDP and population growth rates respectively.

Table 3.3.2. summarizes the results of the projection made under the different assumptions.[45]

Foreign Exchange Implication

To examine the foreign exchange implication of the different cases, 3 different price levels of curde oil are employed. The first (P1) is based on the estimates of the World Bank i.e. 3% per year, net of inflation rise in international oil price between 1980 and 1990.[46] The second (P2) and third (P3) are based on the consideration of the counteracting forces in the world oil market. On the one hand we observe that the current glut of oil is pushing prices (from the official OPEC rate of 34 US $ per barrel) downwards, and on the other hand OPEC member countries are cutting back on their daily output to check any downward move in price. P2 is based on the

Table.3.3.2 Demand Projection : Scenarios

Cases	Assumed GDP Growth rates	GDP Elasticities of CE Demand	Total Demand for CE in 000 mtce			Per capita consumption of CE in Kgce			Share of electricity in total CE in GWH			Share of LF in 000 MT		
			1973	1978	1983	1973	1978	1983	1973	1978	1983	1973	1978	1983
Ia	7.5 *	1.5	969.4	1472.8	2509.7	30.7	41.2	62.1	551.7	838.2	1428.3	613.2	931.8	1587.8
	7.5	1.3	969.4	1396.0	2222.7	30.7	39.1	55.0	551.7	794.5	1265	613.3	883.2	1406.2
	5.3	1.5	969.4	1421.0	2083.1	30.7	39.8	51.5	551.7	808.7	1185.5	613.3	889.0	1317.9
	5.3	1.3	969.4	1352.6	1827.4	30.7	37.8	46.7	551.7	769.8	1074.1	613.3	855.7	1194.1
Ib	1.67 or 1.92	1.5 1.3	969.4	1096.8	1240.9	30.7	30.7	30.7	551.7	624.2	706.2	613.3	693.9	785.0
2	Planning Target as set by CPSC		876.5	1390.8	2222.9	27.8	38.9	55.0	499.0	791.5	1265.1	554.8	879.9	1406.3

* 1973 - 76 is based on average actual growth rate of 4.7% see foot not 36

** For total operating expenditure for production of projected electricity demand see footnote 49.

able 3.3.2 Demand projection: Scenarios (Continued)

Cases	Assumed GDP Growth rate	Demand Equations	Total demand for CE in 000 of mtce			Per Capita Consumption of CE in Kgce			Share of Electricity in total CE in GWH			Share of LE in CCC MT		
			1973	1978	1983	1973	1978	1983	1973	1978	1983	1973	1978	1983
	7.5*		880.3	1513.2	2782.7	27.9	42.3	68.8	501.0	861.2	1583.6	556.9	957.3	1760.5
3a	5.3	Eq. 3b	880.3	1428.9	2177.2	27.9	40.0	53.8	501.0	813.2	1293.0	556.9	904.0	1377.4
	2.5		880.3	995.8	1126.8	27.9	27.9	27.9	501.0	566.7	641.3	556.9	630.0	712.9
3b	7.5	Eq. 3e	870.1	1645.1	4018.1	27.5	31.3	99.3	495.2	936.2	2286.7	550.5	1040.8	2542.1
	5.3		870.1	1521.4	2660.1	27.5	42.3	65.8	495.2	865.8	1513.9	550.5	962.5	1682.9
4	7.5	Table 2.1.3	1068.2	1494.5	2326.4	33.8	41.8	57.5	607.9	850.5	1324.0	675.8	945.5	1471.8
	5.3		1068.2	1447.1	1561.3	33.6	40.5	48.5	607.9	823.5	1161.2	675.8	915.5	1240.3

* 1973-76 is based on average actual growth rate of 4.7 see footnote36

** For total operating expenditure for the production of projected electricity demand see footnote 49

ase 3a Eq.3b $F_t = -52.16 + 0.45Y_t + 0.0024P_t$

ase 3b Eq.3e $L_nF_t = -13.44 + 3.23\, L_n\, Y_t$

ase 4 From table 2.1.3 L_n CEC/Cap. = $-2.92 + 1.34\, L_n$ GNP/Cap.

assumption that OPEC would be able to maintain prices at present level of US $ 34 per barrel for the next five years and to bring about a rise in price at the 3% indicated above. P3 assumes otherwise, that the glut will sustain itself long enough to force prices further down to a floor level of US$ 30 per barrel and along with the decline in world demand for oil keep it there for the five years ahead, and from there an increase at the rate of 3% per annum ensues as a result of increase in overall demand and clearing of the over supply.

Prices are expressed in birr/MT and converted to constant 1964 E.C. prices. Unit prices also include shipping cost of 35 birr/MT.[47]

Alternative Prices of Crude Oil in Constant 1964 E.C. prices birr/MT (shipping cost included)

Table 3.3.3

Price	1973	1978	1983
P_1	374.8	434.5	503.7
P_2	374.8	374.8	434.5
P_3	333.5	333.5	386.6

Export and import projections are based on equations 2.2a and 2.2b. A summary of the results obtained for the different cases is given in Table 3.3.4

The results obtained via the various assumptions and functional relationships by and large show certain similarity which we feel is a measure of the reliability of the results so derived. Of the various results, however, the 5.3 and 1.3 GDP growth rate and

TABLE 3.3.4. FOREIGN EXCHANGE IMPLICATION OF PROJECTED DEMAND (continued)

Cases	Assumed growth rate of export	Prices of ǂ crude oil	Cost of crude oil import in 1964 prices (million of birr)			Export earnings in constant 1964 prices million of birr)			Share of LF in foreign exchange earnings (percentage)		
			1973	1978	1983	1973	1978	1983	1973	1978	1983
3a	7.5	P_1	208.8	415.9	886.8				45.7	69.1	103.5
	7.5	P_2	208.8	358.8	764.9	457.1	601.5	857.1	45.7	59.7	89.2
		P_3	185.7	319.3	680.6				40.6	53.1	79.4
		P_1	208.8	392.8	693.8				45.7	66.9	91.7
3a	5.3	P_2	208.8	338.8	598.5	457.1	587.4	756.2	45.7	57.7	79.1
		P_3	185.7	301.4	532.5				40.6	51.3	70.4
	2.5*	P_1	208.8	392.8	359.1				45.7	54.6	65.3
	2.5	P_2	208.8	338.8	309.8	457.1	501.0	549.8	4577	47.1	56.3
		P_3	185.7	301.4	275.6				40.6	51.9	50.1
	7.5	P_1	206.3	452.2	1280.5				45.1	75.2	149.4
		P_2	206.3	390.1	1104.5	457.1	601.5	857.1	45.1	64.9	128.3
		P_3	183.4	347.1	982.8				40.1	57.7	114.7
3b		P_1	206.3	418.2	847.7				45.1	71.2	112.1
	5.3	P_2	206.3	360.7	731.2	457.1	587.4	756.2	45.1	61.4	96.7
		P_3	183.4	321.0	650.6				40.1	54.6	86.0
		P_1	253.3	410.8	741.3				55.4	68.3	86.5
	7.5	P_2	253.3	354.4	639.5	457.1	601.5	857.1	55.4	58.9	74.6
		P_3	225.4	315.3	669.0				49.3	52.4	66.4
4		P_1	253.3	397.8	625.0				55.4	67.7	82.7
	5.3	P_2	253.3	343.1	539.1	457.1	587.4	756.2	55.4	58.4	71.3
		P_3	225.4	305.3	479.7				49.3	52.0	63.4

* 1973-1976 is based on average actual growth rate of 4.7%, see footnote 36.

ǂ This are assumed prices of crude oil in birr/MT in constant 1964 (see table 3.3.3)

** For the quantity of liquid fuel import(in 1973, 1978 and 1983 E.C.) see table 3.3.2 contd. under the column share of LF in ooo'MT.

Table 3.3.4

Foreign Exchange Implication of Projected Demand

Cases	Assumed Growth Rate of Export	Prices of Crude Oil	Cost of Crude Oil import in 1964 Prices (Millions of Br)**			Export earnings in constant 1964 prices (million of Birr)			Share of LF in Foreign Exchange earnings(Percentage)		
			1973	1978	1983	1973	1978	1983	1973	1978	1983
	7.5	P_1	229.9	404.9	799.8				50.3	67.3	93.3
		P_2	229.9	349.2	689.9	457.1	601.5	857.1	50.3	58.1	80.5
		P_3	204.5	310.8	613.8				44.7	51.7	71.6
Ia.5	7.5	P_1	229.9	383.8	708.3				50.3	63.8	82.6
		P_2	229.9	331.0	611.0	457.1	601.5	857.1	50.3	55.[illegible]	71.3
		P_3	204.5	294.5	543.6				44.7	49.[illegible]	63.4
	5.3	P_1	229.9	390.6	663.8				50.3	66.9	87.8
		P_2	229.9	536.9	572.6	457.1	587.4	756.2	50.3	57.4	75.7
		P_3	204.5	299.8	509.5				44.7	51.[illegible]	67.4
	5.3	P_1	229.9	371.8	601.5				50.3	63.3	79.5
		P_2	229.9	320.7	518.9	457.1	587.4	756.2	50.3	54.6	68.6
		P_3	204.5	285.4	461.6				44.7	48.6	61.0
Ib	2.5	P_1	229.9	301.5	395.4				50.3	60.2	71.9
		P_2	229.9	260.1	341.1	457.1	501.0	549.8	50.3	51.9	62.[illegible]
		P_3	204.5	231.4	303.5				44.7	46.2	55.2
	5.3	P_1	207.9	382.3	708.4				45.5	65.1	93.7
		P_2	207.9	329.8	611.0	457.1	587.4	756.2	45.5	56.1	80.5
		P_3	180.2	293.4	543.7				39.4	49.9	71.9

* 1973-1976 is based an average actual growth rate of 4.7%. See footnote 36
This are assumed prices of crude oil in Birr/MT in constant 1964. (See table 3.3.3)

** For the quantity of liquid fuel import (on 1973, 1978 and 1983 E.C.) See table 3.3.2 contd. under the column share of LF in 000' M.T.

elasticity of demand for CE are considred to be the most likely combinations, given past performance and future prospects. Under favourable conditions GDP and elasticity combinations of 5.3 and 1.5 or 7.5 and 1.3 (in that order) under case 1a; as well as GDP growth rate of 5.3 under case 3a and case 4 can be entertained. While the 5.3 and 3.2 combinations could be held under very optimistic possibilities, 7.5 and 3.2 combinations under uase 3b, 7.5 and 1.5 under case 1a as well as a 7.5 GDP growth rate under 3a seems to be rather unrealistic to deserve consideration. The very high share that LF would claim from foreign exchange earning(in some cases projected to go over 100%)[48] and the not so bright prospect of the export market (in view of the weakness of import growth in the industrialized countries), do not warrant consideration of such high rate of growth. If, however, it is felt to be sound (on the basis of factors not considered here), we would like to point out that CPSC's indicative oil consumption figures case 2) do not seem to be compatible with such GDP growth rate and may need to be revised upward.

A brief comment regarding the underlying assumption is inorder. The underlying assumption of our forecast is one that envisages the historical relationship between the variables to continue. In view of the abnormal periods of the past year, this is a rather strong assumption. Now that relative political stability is attained, one would expect a number of changes both on the demand and supply side. As a result of the increase in economic activity, a rapid increase in CE can be expected. On the other hand, the government would hopefully undertake increased consumption management and conservation policies to combat rising demand.

on the supply side, a move toward import substitution (see section 4.2) measures may be made reducing the share of LFC in CEC.

Not withstanding the above factors, projections made would still be helpful in many respects. For one thing, the five year (1973-1978 E.C.) period used in the forecast is a comparatively short period for such measures and activities to bring marked changes, though some result to this effect may be expected for the 10 year forecast (i.e. 1983). For another, the aim of the paper being an effort to underscore the extent to which the problem could be amplified if the present unmanaged and excessive dependence on LFC continues, such forecast could be informative enough for policy measures to be adopted. Even in the absence of a good data base and the strong assumptions made, we feel that the information obtained is sufficient to generate valid behaviour modes. Moreover, as Simon Kuznets correctly stated,

> "almost every decision made in business and government necessarily rests upon some kind of forecast, of economic conditions... The choice is not between making and not making an extrapolation into the future; it is between making the projection in over and sometimes quantitative terms and proceeding by feel and faith."[50]

Once again despite the aforementioned problems and fully aware of the assumptions made, and also giving due allowance for the drawbacks of applying the method of simple correlation to economic series which by their very nature increase through time, the projections made will throw much light into the extent of the problem to be expected and preventive actions to be employed. It is wise to note that even inaction to solve the problem posed is equivalent to taking strong action. If so it is better to know what lies ahead to undertake corrective measures. As the French dictum goes , *gouverner c'est prevoir*

4. Energy Policy: Importance and Aspects

The foregoing chapters underscore the fact that the problems t that an energy policy must address are Herculean and that a national energy policy to deal with such problems should essentially be an integral part of national development plans. The criteria for choosing among energy policies, which in effect imply multiple rankings of policies depending upon the importance attached to them further require formulating and conduting coherent economic policies at the national level. Moreover, in dealing with the problem, the generally long gestation period of energy projects necessitates development of comprehensive and long term energy policy. Yet it is the absence of any sense of planning or lack of holistic approach to energy problems that is typical of LDC's like Ethiopia. To date inventory of energy resources is hardly sketched and "practical achievements, often narrow in scope reflected a concern for presting than a real desire for economic development." The upshot is frequent divergence between demand and supply requirement. In Ethiopia too, it is the absence of an energy balance sheet which among other things militate against formulating a policy that ensures supply of energy in the amount and form required and at a time and place of interest.

Generally, the relevance of such comprehensive policy for Ethiopia rests on the following factors:

a) The country's excessive dependence on imported fuel which at present is absorbing an increasing share of its meagre foreign exchange earnings, resulting in balance of payments problems, and the equally important political dependence that it is likely to entail

b) The high financial resources, espeically foreign exchange, that the exploitation of potential resources require due to their capital intensive nature, often aggravated by the remoteness of potential sources from main economic center.

c) The grave situation that the traditional energy is in and the need to undertake immediate and vigorous conservation measures as well as to step up the afforestation programme

d) The relatively inefficient use of CE in the face of increasing demand both for development and direct energy consumption

e) The country's declared objective for undertaking socialist construction and the need to meet the very high energy demand that goes with it.

The increasing cost of energy, the close and dynamic relationship that it has with other sectors, etc. requires concrete and urgent rectification of the weaknesses and deficiencies indicated. For rates of oil consumption and import growth could be significantly reduced if both energy production and conservation measures are carried out to their full potential.

Against this background we will look at the foundations of sound energy policy for the country. First we will try to examine factors that operate on the demand side, which will naturally take us to the consideration of the problems of pricing policy and efficiency of energy utilization. In the second part we will examine ways that could help to reconcile energy requirements with competing claims of different economic sectors. It is here that we deal with conservation policies as short run measure of coping with the supply problem. In the sections that follow we will examine, albeit briefly, the future of supply possibilities by looking at the country's energy potential and the ease or difficulty of its exploitation.

4.1 Demand Management Policy: General Aspects

The possibility of substituting one form of energy for another makes the effective use of fiscal and pricing policies very crucial since they play decisive role in bringing desired shift in consumption. In order therefore to make substitution from lower to higher uses and reduce the energy cost of output the establishment and maintainance of a structure of relative prices and fiscal measures is very important. In fact the volume and proportion of the different forms is finally going to hinge on the priorities that is reflected by the price structure and fiscal in.centives. If such structure fails to reflect the opportunity cost of the energy involved, it could create wastage and distortion in the entire energy consumption system.[2] Opportunity cost consideration would therefore necessitate the setting up of priorities at the national level among the principal uses of energy . "For example industrial versus commercial, or household activities, public versus private transport, energy intensive versus non-intensive activities--- and ensuring that government policies generally are consistent with these priorities."[3]

Hence in order to ensure efficiency it is imperative to try to find out whether all units of energy derived from different sources are equally or sufficiently economic at prevailing prices. Moreover, in the analysis of future trends in CEC - especially of hydrocarbons - a distinction needs be made between demand linked to economic development (coming mainly from expansion of production) and demand deriving from the substitution of one form of energy for another.

4.1.1 The Relevance of Policy Instruments: Price and Fiscal

As stated earlier CE is largely used for productive activities and given the technological rigidity[4] the room for substituting one form of energy for another is very small. This was further revealed by the price inealsticity of demand for LF obtained in the preceeding chapter. Whether based on these or other considerations, prevailing opinion generally seems to be one that underestimates the capacity of price and fiscal policy to bring about desired shift in consumption or enable to maintain priorities in the energy consumption system. We hold that such view is quite erroneous and fatalistic. While the short term price elasticity of demand is admittedly very small the same could not be said about the long term elasticity. As the adjustment period increases the elasticity could get larger. Even in the short run there are certain adverse trends like substitution of traditional forms for CE - that efficient pricing policy could help to combat. In the consideration of demand management policy, our argument for such measures would rest on, inter-alia,

a) Price structure that currently reflects opportunity costs of the various forms of energy would help as a signal, as to the choice of technology to be made for future production, thus leading to long-run employment of technologies that are more efficient in their energy utilization or better still, depend on indegeneous energy sources.

b) Even with employment of existing technologies higher domestic prices would lead to serious consideration of energy conservation methods - a point to be dealt with at length in section 4.1.2

c) Such price structure will curb the present rapid and wasteful growth on CE use - particularly in household consumption - and ease the pressure being put on CE deriving from the substitution of traditional energy for CE (say fuel wood for kerosene or butane gas=. In fact, though rather limited a shift in the reverse direction could in some cases be affected. Relatively cheaper price for fuel wood could lead some families to replace CE (Electric stove, butane gas) by local cooking appliances using charcoal or eucalyptus wood etc. or maintain alternative use.

d) Underpricing prevents the government (and other energy suppliers) from earning sufficient revenue to finance future investment or augument existing capacity. Revenue lost as a result of tax reduction or resource spent on subsidization would only lead to aggravation than to easing of the problem.

It is within the context of these hypothesis that we undertake the discussion that follows.

4.1.1.1 Fiscal Policy and the Price of Petroleum Products

As in many countries the need for an effective energy price policy came to increasingly be felt following the sudden quadrupling of crude oil prices during late 1973 and early 1974, and subsequent increasesthereafter. In 1970 crude oil used to be imported for about 1.82 U.S.$ per barrel. Currently this price stands at about 34 U.S.$ per barrel, after reaching a record level of 40 U.S.$ per barrel in 1979. Barring other additional costs (shipping, insurance, etc.) we see as increase of over 1700%.[5] How then did the domestic price respond to such a change. Not much. In fact prices to consumers of petroleum derivatives increased by considerably lower percentages. In 1970, the retail price of ordinary oil was 0.42 cents per litre at Addis Ababa. The corresponding price in 1982 is 1.19 birr per litre. This price is low compared to neighbouring countries (in Kenya, Sudan and Tanzania where prices are 1.59, 1.87 and 2.81 birr per litre respectively) and more so when compared to the 2 birr averages for developed countries.[6] Despite the series of price increases made (May 1978, April 1980, and March 1981 - see Appendix 4a), domestic prices have never been able to reflect the international price situation. Thus prior to the recent price increase, the government was paying 250 million birr annually "in order to cover the additional expenditure created by the gap"[7] between domestic and international prices. Even today, the government reportedly pays a monthly subsidy of 1.5 million birr.

The government subsidy is of course intended to shield the consumer from the hardship that such a high cost would entail. Though one cannot fail to appreciate the good intention behind it, the effect of such a move in the long-run development of the country would lead one to question the wisdom of it. Reluctance to pass higher prices to domestic users would only serve to maintain pressure on CE market and to eventually drive energy cost further up. Moreover, since the problem is not temporary, and in fact here to stay, one would wonder for how long the government can continue to subsidize fuel consumption. Not only would this encourage waste, but also distorts the priority concerns in the energy system. First,all the subsidy paid by the government is a real cost; a cost that could have equally been used to develop alternative energy sources, promote measures that would ensure efficient utilization of energy etc. Primarily, given that 65% of petroleum is consumed by the transport sector, the 250 million birr annual subsidy could have been used <u>inter alia</u>, a) to expand the public transport system, b) to improve on road conditions, c) lay the ground for the establishment of mass transit system, etc.

Secondly, it could be said that subsidy has encouraged wasteful use of energy by consumers since they now find it relatively cheaper than it would have been if otherwise. Higher prices will obviously force consumers to plan efficient use, or to find alternative means etc. One can imagine the number of unnecessary trips that could be avoided or ones that could have been made using public transport than private cars, etc. More of this later.

Thirdly, the measure is biased towards the urban population which is only a minority and makes more use of CE as compared to the vast majority of the rural masses whose need for CE is very minimal (compare the subsidy with the 30.7 million birr alloted to the Forestry Authority in 1982).[8]

Fourthly, it can be argued also that lack of fair treatment regarding various energy forms has discouraged (at least not encouraged) investment in production of other energy forms, in R & D etc. to ensure maximum technical and economic efficiency for the national economy.

Although it would be presumptous to suggest specific areas in which the resource released could have been used, there is no doubt that our demand for fuel oil would have decreased had we used it in any of the measures cited. Fiscal measures adopted do not also lead to the reduction of demand for fuel oil. For instance, the move taken in 1975 to reduce taxes on imported oil not only reduces government revenue, but also distorts development priorities by diverting real resources to non priority areas. In fact diminishing tax rates so as to lower overall inflationary impact of increased energy price can achieve only temporary respite. For sooner or later increased demand will lead to higher energy cost putting further strain on the economy. Nevertheless, the above discussion should not be taken to imply the complete absence or denial of the need for equity considerations. It only underscores that tax reduction or subsidization should (if need be) discriminatory and essentially of short term nature.[9] Based on the results to be obtained or objectives pursued (social or environmental), it should be

Specific to a certain group, sector or subsector, region, etc. that is aimed at [10] and need be revised to reflect changing situations.

Eventhough the "double energy crisis" we are in makes substitution between traditional and CE forms very difficult and painful, long and short-term considerations dictate us to undertake a conscious effort to increase the elasticity of substitution in favour of the traditional forms. While our ability to influence supply conditions and the price situation of CE forms (petroleum and derivatives), which are virtually determined by producing countries (OPEC) is nil, those energy forms dependent on domestic factors could with appropriate policy be made to be more responsive to domestic needs. Despite the critical condition in which it is presettly found, with determined effort and appropriate policy there is no reason why massive afforestation programmes could not reverse the present trend and make the supply of fuel wood abundant. This will definetly ease the substitution from traditional to CE which is encouraged by the subsidization measure and rising cost of fuel wood.[11] Furthermore, the price structure and fiscal measures used should provide sufficient incentive to encourage investment in the production of such traditional forms i.e. planting of trees, and improving convienience and efficiency of traditional implements that use fuel.

Before concluding this part there are two points that are worthwhile to note. One is the fact that even though generally held to be insensitive to prices government organizations to some degree do respond to higher prices since it eats into their budget.

In such a case one can suggest a host of additional measures that could be taken to combat wasteful utilization. Such policies are mostly sector specific (i.e. depend on the nature and extent of energy use) and essentially a conservation issue - to be dealt with later. Suffice it to say that government consumption is not inelastic as some people would have us believe. In fact with effective and adequate administrative measures in the form of rationing, budgeting, mileage recording, etc., satisfactory results could be attained . Most important however, is the need to consider energy as the central element in development planning (more of this later).

4.1.1.2 Electricity Tariff Rates

Analysis of electricity tariff rates also reveals a situation of under-pricing. Although detailed information is hard to come by, it is known that the self contained system (SCS) is continually subsidized by the inter-connected system (ICS). The level of subsidy which o in 1977 alone was about 4.24 million birr,[12] explains the sustainance of the tariff rates of the SCS below the cost of production at a time when high cost of fuel is causing havoc to the economy. Since electricity so derived is largely consumed by the well to do section of the population, such subsidization cannot be justified on equity or other grounds.

As pointed out earlier, whatever the reason for subsidization it would be well to also consider where the resouce to be used as subsidy comes from, for how long the subsidisation will last, and the opportunity cost involved in terms of scale of priority areas of development.

In addition to factors cited the huge capital requirement of electricity production further emphasizes the need for tariffs to also "yield revenues sufficient to cover accounting costs and in addition, make a substantial contribution to the self financing of future system of growth."[13] Failure to take heed of such considerations in tariff setting principles could put the whole economy in jeopardy, in view of the very large expansion of supply requirement to meet the demand of the planned industries,[14] and the growing demand of households and other sectors.

Due to its wide acceptance in many countries and the relatively easy data requirement, electricity tariff is determined purely by accounting criteria. Such approach spreads total accounting costs among consumers in the determination of tariff rates[15]. In Ethiopia too, such methodology was adopted on 1964 E.C. based on the study made by British consultants. The method is believed to have been partially revised in 1972 E.C. but for all practical purposes the accounting criteria is essentially still the basis of tariff setting.

In the system of regulating public atilities developed countries generally follow an approach to tariff that has not much to do with efficient allocation of resources. These countries can afford to follow such an approach, but not LDC's like Ethiopia. For the latter, efficient allocation of resource figures more important - specially at this stage of their development. The "tradional" approach of tariff setting takes little account of such consideration. In fact, recent studies have shown the short comings of this approach.[15] To begin with it is static in a sense that it regards resources as cheap (or as expensive) as they were in the past. In our era of rising general price levels, what one needs is a forward looking estimate. Our concern should not be to recover sunk cost - a point the "traditional" approach is concerned with- but to set prices to the value of resources that are used. If so, marginal cost pricing which shows the impact on resource cost of changes in consumption is more appropriate. Since it is based on spreading costs among consumers the accounting approch yields average cost and reflects the cost the consumer bears to acquire an extra unit of output. What is rather required is a method that shows "a measure of the extra resources required to produce it,"[17] i.e. the marginal cost. Failure to set prices at least equal to the marginal cost amounts to making" the cost to the consumer less than the related cost imposed upon the enterprise or the economy as a whole.)."[18] Table 4.1.0 and 4.1.1 show the operating expenditure and tariff rates of EELPA (respectively). Looking at the rate of increase of operating expenditure it would not be difficult to see the necessity of a tariff setting approach that duly takes such rapid increase in cost.

TABLE 4.1.0:- Expenditure in Cents per KWH sold

Year E.C.	Expenditure /KWH	Relative 1964=100
1960	6.35	81.72
1961	5.27	67.82
1962	7.13	91.76
1963	7.47	96.14
1964	7.77	100.00
1965	8.00	102.96
1966	9.12	117.37
1967	10.23	131.66
1968	10.37	133.46
1969	10.72	137.97
1970	11.20	144.14
1971	10.97	141.18
1972	12.76*	164.22
1973	13.33	171.56

*are based on budget figures

Source: Compiled from EELPA documents

The existing tariff rates do not indicate (to consumers) whether or not consumption is taking place at peak load i.e. when maximum use of the electric supply is being made of. Absence of such consideration regarding the composition of load is one big shortcoming. Knowledge of who uses how much electricity as well as the time and purpose of use is very important since it enables discouragement of loads that result in higher costs and conversely to encourage those that involve low cost. The absence of peak load timing considerations (except for Asmara region), prevents such useful practice. The necessity of peak load pricing, at a time when the small reserve is fastly being wiped out cannot be over-emphasized. Moreover, when demand begins to outstrip supply one will be

TABLE 4.1.1 Tariff Rates, ICS and SCS (in cents per kwh)

	Interconnected		Self contained	
	1964 - 71	1971- (existing)	1964-71	1971- (existing)
Domestic tariff				
for first 100 kwh	15.0		15.0	
Balance (rest)	10.0		10.0	
for first 25 kwh		15.0		15.0
for next 75 kwh		17.0		18.0
Balance		12.0		13.0
Commercial tariff				
for first 300 kwh	15.0		19.0	
Balance	10		14.0	
for first 50 kwh		15		19.0
for next 250 kwh		18		22.0
Balance		13		18.0
Large low Voltage Industrial				
for first 200 kwh/month	6.0	9.0		
for next 300 kwh/month	5.0	8.0		
Balance	4.0	7.0		
for first 10000 kwh/month			10.0	13.0
for next 10000 kwh/month			9.0	12.0
Balance			8.0	11.0
Large high voltage industrial				
for first 200 kwh/month		7.5		
for next 200 kwh/month		6.0		
Balance		5.0		
for first 10000 kwh/month	4.5		10.0	
for next 10000 kwh/month	3.0		9.0	
for next 300000 kwh/month	2.0		8.0	
Balance			7.0	
Street Lighting	11.0		11.0	

SOURCE: EELPA

forced (at least until additional supply is forthcoming) to resort to physical rationing (load shedding). The negative aspect of such practice of course need to be considered. The "social costs of load shedding including losses of industrial output, and nuisance and cost to consumers of having to substitute candles, batteries or oil heaters or having to do without",[19] could be quite high. Though the only way of averting such possibility is taking timely action to avoid supply shortage, peakload pricing offers a better and economic way of rationing their load shedding if found inevitable, at least until one is able to overcome the deficiency.

The declining block tariff used by EELPA doesn't also make peak period consumption more expensive that non-peak periods.[20] Time-of-day metering and peak load limiters however do tell consumers that peak hour consumption is expensive. In short the need to change the tariff structure so as to introduce incentives described and to relate such incentive effects "to the cost and availability of supply"[21] is long overdue. "To change a little for a load that imposes heavy costs may encourage wasteful use of electricity, while to charge a lot for a load that can be met easily and cheaply is to signal the consumer incorrectly."[22]

Given the possibility of substitution between the different energy forms, load analysis could also be used to see the likely shift, that could occur. Since, say butane gas competes with electricity for cooking, incentives to consumer to use low priced off peak periods may encourage shift to the latter or may even lead to less use of fuel wood, if such substitution is figured out to be relatively more beneficial to the economy.[23] In any case, the possible outcomes need detailed study which is beyond the scope of this paper. Nor is it the intention of this paper to deal with the kind of tariff rate to be established and the metering policy to be followed or to indulge in priority ranking of forms of energy. All it tries to suggest is that the tariff policy should be dynamic and foreword looking. This for two things. Firstly the continous increase in cost of equipment, maintenance etc. which leads to increase in production cost, need to duly be reflected in the tariff rate, so as to ensure efficient allocation of resources. Secondly, the tariff rate should yield a minimum rate of return to cover its costs and still be able to at least finance a certain portion of future capital expenditure.

In general pricing and fiscal measures should encourage energy conservation and development of alternative energy sources. In conjuction with this increased investment in energy saving equipments and techniques need to be undertaken. As aptly stated by World Bank energy efficiency need to be "considered as the principal element in economic planning and energy demand management must take its place with other forms of economic management."[24]

4.1.2 Conservation Policies

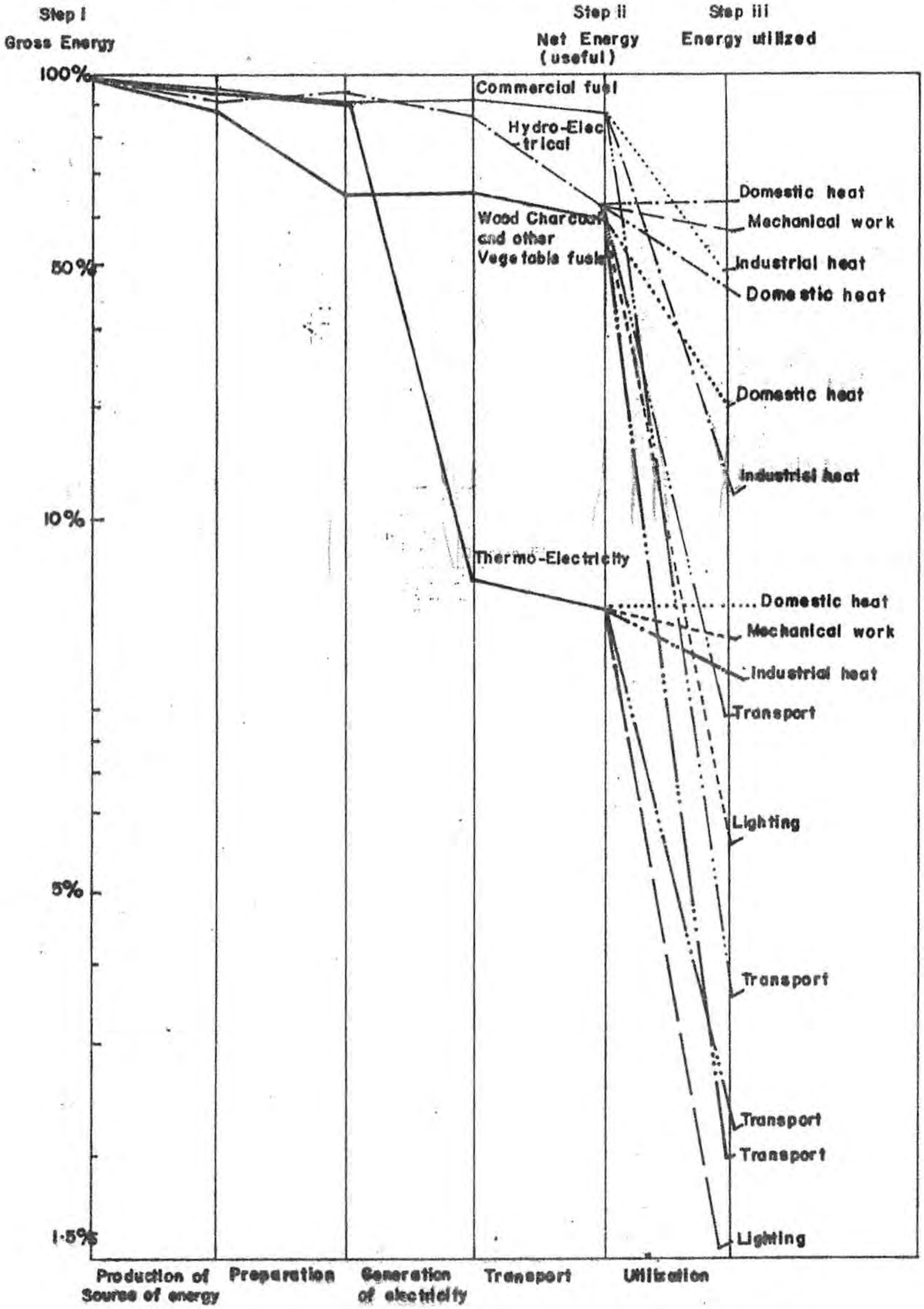
The desirability of abundant energy supply is manifest in every direction. The very high cost it involves, however makes its planning and conservation the core of overall development policy. Gone are the carefree days, or as some people say, "the joy ride" is over. Energy has to be conserved and its use planned. By conservation we understand "the strategy involving the maximum improvement of energy utilization system and methods so as to cut the energy requirement per unit of production (or well being) without compromising socio-economic development."[25]

Though the need for undertaking conservation and demand management policy is theoretically widely accepted, few countries have so far considered its practical implementation. In fact "surveys made by UNDP among one hundred governments show that conservation of energy ran as last if at all among all priorities for new and renewable sources of energy."[26]

Yet according to studies made by various agencies conservation "by itself might made available more energy than all other sources of renewable energy combined.[27]

It is true that amount (degree) of energy to be saved via conservation and demand management policies could vary widely among countries. But in no country can its contribution be underplayed. Ultimately the inpact of higher energy costs on the growth prospects of countries like ours depends on the domestic policies implemented to manage the increasing energy inputs of the economy, i.e. to increase the amount of useful work (efficiency) that is obtained from present use of energy.[28] (see figure 4.1). In light of this we will examine possible energy

Figure 4:1:0 Latin America Approximate Efficiency of Various forms of Energy By Utilization (step i—iii) in the Group of Countries with Advanced Techniques (Semi—Logarithmic scale)



Source: United Nations, Energy in Latin America, 1957, p81 conservation measures in the different sectors of the economy, i.e. in Transport, Households, Industry, Agriculture and Power.

Transport

Transport being the highest consumer of petroleum (over 65%) it is in this sector, notably in road transport, that one can expect to find substantial gain in the effort of saving fuel.

In looking at ways of increasing efficiency and combating waste in the transport sector we need to distinguish between energy that is saved through improvement of existing structure (like roads, type of vehicles etc.) and that of combating wasteful practices. Regarding the former, shifting "traffic from less to more efficient carriers is generally suggested. This calls for encouragement of river and rail transport which require between 100 and 200 per cent less fueld per ton kilometer.[29] River transport does not have much scope for Ethiopia as most of the rivers are not navigable. For the limited areas where it could be used (for instance Baro, lower Omo etc.) effort should be made to make the best of it. Except for the very high initial capital cost involved, rail transport is an efficient carrier specially where bulk transport is the case. Notwithstanding the formidable capital cost, establishment of rail links between major activity areas is absolutely essential and every effort needs to be done to search for long term loans to realize it. In view of the rapid increase in capital costs an early start is important since every passing day makes its establishment more and more remote. Establishment of electrified trolley buses or trams for major cities like Addis Ababa is also necessary, again in spite of the high initial cost.

Given the fact that the largest share of freight is carried by road, improving efficiency of road transport gives additional possibility for conservation. Though hard to quantify the deplorable condition of the roads, the high proportion of gasoline trucks which are less energy efficient as compared to diesel trucks, [30] poor maintainance of existing equipment which lessens efficiency etc. all lead to a higher fuel requirement per ton kilometer of freight transported.

According to World Bank estimate increasing the energy efficiency of vehicles can offer (developing countries) savings of up to 20 per cent, estimated to be US $ 11 billion on 1980, without affecting the quality of trnasport service or requiring behavioural changes on the part of consumers.[31]

Poor management and inadequate services moreover lead to low quality of public buses which in turn helps to increase the attractiveness of private cars. Considering the present 6.6% annual growth rate of the urban sector,[32] unless ways are urgently sought to provide the necessary infrastructure for providing mass transit system, heavy demand will continue to worsen the present condition of the urban transport system. The need for mass transit systems between major and proximate towns is also a salient point.

TABLE 4.1.3 Ethiopian Transport Fleet (1979)

Types	Number
Cars - Gasoline	38,382
Cars - Diesel	2,001
Buses	124
Freight trucks	5,546
Tank trucks	582
Subtotal Diesel	8,253
Grand Total	48,635

Source: Beijir, p.4

High proportion of private cars would entail high maintenance costs, large expenditure on import of oil, high capital investment on highways, parking lots etc. - services that are becoming increasingly difficult to provide. In general restriction on engine capacity, and switching to smaller and efficient cars, taxation of vehicle purchases, foreign exchange control measures etc. are among possible measures to minimize the effect of private cars. The complimentarity of gasoline and cars can also be employed to reduce demand for private cars by making the price of gasoline reflect its opportunity cost. Although the short turn elasticity to price trends could be small, the long-term elasticity would definitely be much greater. Moreover price induced gasoline mileage target may in the long run prove to be a more practical measure of conservation than mandatory ones which are hard to enforce in many cases. As for the second approach measures like town and industrial planning (se 4.1.1) curbing the horizontal growth to the extent possible, minimizing unnecessary mobility of the urban population say by enabling workers to reside nearer to their work place, students to enroll in nearby high schools, provision of service facilities like shops in neighbourhoods, improving the telephone service etc., all help to reduce mobility, saving both time and energy. Individuals can also undertake conservation measures in their daily activities. Car pooling practices by individuals could reduce fuel and maintenance costs, avoiding empty backhauls by planning trips, limiting speed, using telephone and other media of communication to run business where possible, etc. are among energy saving practices. Wasteful energy consumption resulting from abuse of power and responsibility is also an area that requires remedial measures.

Industry

The industrial sector uses electricity more than petroleum, 55 and 12.3 per cent respectively for 1979. The total share in CE stood at 21.5 per cent in 1976. Relatively speaking industry is among the most energy intensive (though intensity could vary tremendously within the sector) whose productivity is closely related to the quantity and type of energy utilized. Along with modern transport, industry is a sector whose demand for CE is bound to increase highly in the years to come. Improvement on efficiency and shifting to domestic sources (where possible) are among the measures that figure as important in this sector. In order to find causes of low efficiency and duly undertake corrective actions one needs to make complete study "of each industry, and the methods of using energy, the sequence of operations the degree of rationalization, the equipment used etc." in light of modern energy efficient techniques.[33]

Simple changes and improvements in existing production processes, coversion from wet to dry processes and from oil to electricity or even coal firing in cement production, retrofitting etc. could bring substantial gain.[34] A good case pertaining to such improvement is the recent agreement reached between the Ministry of Industry and EELPA in order to shift 10 industries whose boilers are using gasoil and fuel wood to electricity. According to information obtained from the Ministry of Industry, such a move has a number of advantages both from the sector as well as national economy point of view. Among the advantages cited: a) By exploiting a domestic energy source (electricity) such a move would save the nation 24 million litres of gasolin annually. The foreign exchange saved could be thus used for other pressing needs.

b) trucks along with their trailors that were used in order to transport the gasoil from Assab to Addis Ababa (taking a total of more than 1000 trips) are now relieved to be of use elsewhere.

c) Since three of the ten factories used to consume 40,000 m^3 of fuel wood, the shift made would contribute towards easing rapid deforestation.

Seen from the point of view of the industries it is believed that they could save up to 12 million Birr annually[35]. It is also known that electric boilers are less costly in terms of maintenance and the risk of production stoppage due to supply failure arising from transport or other problems, will be minimized. EELPA's effort to expand its services could also be enhanced as a result of the substantial increase in its revenue.[36]

The above is just a simple yet very illuminating example of the possibility of long-run substitution. The possibility of similar measures in vast, though not possible for us to enumerate them here. For instance, since the efficiency level of equipments could vary depending on ways of operation simple training accorded to those engaged in production or consumption of energy can contribute significantly. In short we hope such increase will spur others to emulate and actively search for ways and means to increase efficiency.

Households

Households' share of CEC is very low showing the strong dependence on traditional energy. In 1976 it (residential and commercial) accounted for only 3 per cent. Consumption has presumably increased since then, but by all indications it could not have gone greater than 5 per cent. Even in the most urbanized areas, firewood and charcoal are widely used while the same (along with crop residues and cowdung) constitute virtually all the energy used in the rural sectors. In view of the double energy crisis faced, policies to be pursued with respect to substitution (traditional to CE) that occurs in this sector pose a dilemma as to which to encourage. As the World Bank notes:

"Controls over the cutting of wood, or the delivery of wood and charcoal to towns (widely practiced here) are likely to be inefficient, and promoting a shift to commercial fuels by price subsidies obviously has severe limits when the population of towns is growing as rapidly as it is." 37

The problem is quite pressing, and there is no unique solution to offer. What one can at best hope is to offer a spectrum of possible measures both on the demand and supply side, that could reinforce one another to ease the problem. On the supply side, demanding plantation of more trees for everyone cut, introduction of fast growing species to mitigate differences between regeneration and offtake rates, reinforcing existing organization for afforestation, stepping up the afforestation campaign, developing more nursery facilities, restriction of open grazing, providing proper incentives for peasant associations and individuals who plant trees, planting in marginal lands, around urban areas, etc.. On the demand side, important measures include designing of more efficient stoves and devising ways to increase pyrolitic conversion. The study made by the Faculty of Technology is one such attempt. It shows the determinants of the heating values of domestic fuels and efficiency of local appliances.[38]

According to the report of the study the loss of heat is less when cooking with metal stove than by "Gulicha" and the efficiency ranking is as given in Appendix 4f. After listing the reasons that contribute to the loss of heat (such as radiation from the heated surface, convection of air passing the heated surfaces, fuel burning outside the reach of utensils, thermal resistances of the appliances themselves), the report goes on to suggest ways to reduce heat loss.

These include use of white or polished surfaces and reduction of the area of heated surfaces, very low air velocity over the appliance, directing flames towards the utensils, combustion in a closed chamber etc. The report further notes that utensils made of materials of high specific heat and low thermal conductivity (eg. clay) cause excessive initial heat loss but have an excellent property of retaining the heat for a long time.[39]

The logical conclusion is therefore not to use these utensils for a short term cooking. In general such studies need to be encouraged and efficient appliances developed. Efforts currently being shown by the Science and Technology Commission though modest, are a step in the right direction. Educating the public about ways and means of efficient energy use practices can also help tremendously.

Agriculture

CEC by the agricultural sector is relatively small. This reflects the dominance of subsistence farming. At present, yield increasing technology is largely used by the 45 or so state farms throughout the country. Though currently area under tractor cultivation is estimated to be less than 1 per cent, it is expected that in the coming decade the number of state farms could be as high 193 with 1 million hectare area of coverage. It is therefore here that, "energy demand will have to be carefully managed so as to sustain technological change in a situation where the real costs of inputs to produce basic food-stuffs are likely to rise more rapidly than the price of those products."[40]

The 2.5 per cent general population increase and within it of the 6.5 per cent or so increase of the non-agriculturally employed population will require increase in food production. The need to meet the increasing raw material as well as foreign exchange through higher export of agricultural products would also require a rapid rise in agricultural output and productivity. Modern yield increasing techniques would of course all require substantial use of CE (be it mechanization, chemical fertilizers, irrigation or pesticides). The resulting energy requirement and the financial implications of it is of course not difficult to imagine. "Turning to liquid oil for tractors and vehicles the total cost to operate an area of some 250,000 hectares is estimated to be 22,512 Birr which cost is expected to rise to 94,787,000 Birr by the year 1990 in order to cover an area of 1 million hectares. Last year's cost figures indicate that fuel and lubricants were an average 20 per cent of direct cost."[41]

As was discussed earlier introducing bio-conversion of animal and agricultural waste, as well as possible use of solar and wind power could in the years to come be hoped to contribute to the energy requirements of these farms. Till then an all out effort should be waged to minimize CE use. Good farm practices could make significant contribution towards efficient use of energy. For instance, only 30 per cent of fertilizer application is believed to be used by plants, while the remaining is wasted. Pump irrigation is practiced in areas where gravity irrigation could have been used, or worse still vast quantities of water pumped by oil fuelled pumps is wasted etc. Noting the very high scope for increasing efficient use of inputs in the developing countries, the World Bank holds further production increase as feasible "with present technologies provided there is vigorous expansion of extension services backed by applied research."[42]

Power

A relatively different area in which the improvement in energy efficiency could bring substantial gain is power production. All power systems inherently incur energy losses in generating stations, and resistance losses in transmission and distribution networks. In our case the essential issue involved here is to minimize the energy loss encountered in refining and distribution in case of petroleum and generation and transmission in the case of electricity. The problems and prospects encountered in both cases were briefly discussed in chapter 3 and need not be repeated here. We will however, make few comments regarding electricity generation in thermal power stations, because of its very low efficiency and the existence of prospects for improvement. in view of the high cost of oil the following measures are worth considering

- discouraging the construction of new, exclusively oil fired power stations;
- encouraging the conversion of existing oil fired capacity to more plentiful hydropower;
- linking up thermo-electric with hydro-electric power stations;
- directing effort to the reduction of the use of heavy fuel oil as a primary energy source in those areas where efficiency is considered very low.

Before closing this chapter a brief comment on government consumption (85 - 90%) is in order. Government consumption can be seen under two broad categories, i.e. the productive sector and the non productive or the admistrative sector. The former pertains mainly to industry, power, state farms and corresponding transport - sectors discussed in the foregoing pages.[43] It is in the later that we find excessive squandering of energy resources. Though hard to quantify substantial amount of waste exists, coming mainly from the reckless and irresponsible use of government cars. It is ironical to see the proliferation of such cars for bureaucratic use at a time when one calls for an all out effort to save energy and revert to the use of public transport for transport services. Unless urgent measures are taken to check such unhealthy trend the damage that it could bring on the whole economy could be enormous.

Government consumption is not inelastic as some people would have us believe. In fact, with effective and adequate measures in the form of limiting import of such cars, budgeting, rationing, mileage recording etc satisfactory results could be attained. Obviously such practices are sector specific (i.e. depends on the nature and extent of energy use and the form of energy used). It also depends on the understanding, foresight and skillfulness of the energy user. If not for the limited space we could enumerate the thousand and one ways of energy saving practices. Suffice it to note that most of such practices are easy to detect and that every conscientous and responsible citizen can find a number of them in his daily activities.

4.3 Overview of Possible Shift Towards Indigenous Energy Sources: Import Substitution:-

The need to project future demand for energy emanates from the fact that knowing the future supply requirements of the various energy forms, the government can direct its policy instruments to the maximum exploitation of domestic sources to meet such demand. It is only after domestic sources have been fully appraised that one tries to fill the gap through imports. Such a move is contingent upon the comprehensive study of the potentials of the different sources of energy, technical knowledge of the volume and development possibilities, the priorities to be accorded for the development and use of various forms of energy based on social cost benefit analysis, examination of the financial requirements and the possible sources of financing, the substitution elasticity of the various forms of energy etc. These enables the government to have some idea of the incentives, legislations, etc. required as well as the formulation of policies regarding prices, subsidies - so as to orient the consumption pattern towards those forms of energy deemed advantageous to the nation.

Regretably, except for the numerous reports loaded with the now trite phrase "the enormous potential the country has", nothing substantial has so far been done. It was (and is) lack of such detailed studies and an energy programme reflected in the insufficient human and institutional copabilities, which among other things, has led to the inefficient use of domestic resources as well as continued heavy dependence on imported sources of energy. Unfortunately, this study too does not claim to provide much in this regard. As indicated earlier such a task would demand no less than the pooled work of different practitioners organized at a national level with substantial financial resources to undertake the extensive and intensive field work which the study by its very nature necessitates. The present study will, therefore, make a very modest and cursory assessement of the extant potential and the extent of substitution possibilities based on the review of different literature.

4.3.1 Geo-Thermal

In terms of potential, geo-thermal energy presently ranks second to hydro-electric. As a recent report of experts on geothermal energy indicates, Ethiopia lies within the best zones for geo-thermal resource development which comprises the great Rift Valley, extending from the Red Sea in the north to Mozambique to the south, through the territories of Djibouti, Ethiopia, Kenya, Uganda, Tanzania and Mozambique.[44]

Many other areas of Africa are also known to have such potential, though no significant exploitation is undertaken except for a small sta-station at Kuabukwa in the Shaba province in the Republic of Zaire. Despite the virtual absence of economic exploitation, many countries have now actively undertaken measures towards this end. Not only is Ethiopia among these countries but also one in which prospects look very promising. The geothermal areas in Ethiopia, considered "inexhaustible on a human time scale", cover more than 100,000 square kilometers and (with the exclusion of Iceland) are reported to be probably the largest on land geothermally active area in the world.[45] The geothermal areas are two, namely the main Rift Valley and the Afar Depression. Study on it started in 1967 by the Institute of Geographical Surveys in collaboration with the University of Pisa and the Italian National Research Council. Based on the recommendation to carry out investigation in the Afar Depression, the first phase was carried out in 1969-71 this time in collaboration with the UN - UNDP. This project is reported to be the earliest extensive geothermal reconnaisance and exploration programme covering the whole of the Rift Valley - an area totalling 160,000 square kilometers.[46] Based on studies undertaken (geological mapping, geochemistry, hydrogeology, infra-red survey and an extensive inventory of hydrothermal manifestation), the existence of an enormous potential was reported. Accordingly sites were selected for detailed study. The following are indicated in order of their preliminary prospects.

a) Tendaho Graben in the Afar Depression

b) Dallol in the Afar Depression

c) The Lakes Region in the Rift Valley.

The geothermal areas along the lakes region of the rift valley was in turn divided into three prospective areas, a) Lake Langano area, b) Gorbetti caldera area, c) Northern Lake Abaya area.

It is reported that despite the first priority recommendation given to the Tendaho Graben, Northern Langano was chosen for further detailed work mainly due to its proximity to Addis Ababa and the National Transmission grid system.

The study carried on the three sites of the lakes region showed the areas as being more or less of similar geological characteristics and the existence of geothermal reservoirs at depths of 1500 meters with subsurface temperatures in the order of 200°c to 250°c and in some areas even higher.[47] The positive results led the Ethiopian Government with aid acquired from the EEC, the UN and its own fund to undertake the selection of deep exploratory and production sized well sites. The drilling of the first of nine exploratory drill holes started on 7th November 1982 with the aim of locating "a geothermal fluid reservoir for use in the generation of electricity from a 30 MW generating plant."[48]

Similarly the exploration study in the Afar Depression continued with emphasis on the most promising sites, Tendaho Graben and Dallol. The study undertaken has come up with a preliminary conclusion showing the existence of geothermal reservoirs at a depth of about 1,000 meters with a temperature in the order of 250°c. The next phase of exploration is to continue.[49]

Geothermal energy like many others has both its advantages and disadvantages. Among the demerits we find the need for extensive geological research and the often very high cost of drilling. Moreover the location of the geothermal field and resource characteristics of the area in terms of its economic needs and potential, figures prominently for optimal multi-purpose utilization. Unless for example there are industries nearby to utilize the low cost hot water or steam - these two main components of geothermal resource could be wasted, since it would not be economical to transport them to distant areas. Hence the use of such available hot water and steam for, say, processing of agricultural or forestry products, for heating, refrigeration, air conditioning, etc., would allow multi-purpose utilization, thereby making efficient exploitation possible.

The advantage of geothermal energy ranges from offering electricity cheaper than coal, oil, or nuclear power and of being of low capital investment and operating costs as compared to hydro power to being a source of mineral byproducts such as lithium, rubidium, cesum, boron, strotium, helium gas and sodium, potassium, magnesium and potassium salts etc. In light of rising oil prices and the uncertainties attached to future supplies, the importance of geothermal energy in saving foreign exchange and its contribution to the strategic goal of self-sufficiency in energy cannot be overemphasized. Moreover, since geothermal power is technically easy to install and simple to operate it lends itself to easy electrification of deprived areas and the possibility of increasing the size of the small power plants as consumer demand increases with growth of economic activities.

Geo-thermal sites are generally noted for their therapeutic benefits and of being popular tourist sites like Sodere - factors that contribute to the earning of the much desired foreign exchange. Furthermore geothermal is "the only resource which could provide the necessary water supply, heat supply and co_2 supply for year round green house farming".[50]

Considering the merits cited, it is with great hope and expectation that we look forward to the early start of operation of our country's geothermal plants.

4.3.2 Other Sources

In what follows we will describe briefly different kinds of energy having various degrees of relevance but all of some potential in their contribution to Ethiopia's strategic move towards self sufficiency in energy.

The sources are divided into two groups. The first group comprises conventional energy which virtually is the same with commercial energy and of which hydropower and fossil fuels are most important. The second group covers the main non-conventional energy sources, both old and new. Their common features are that they are renewable, and being much less concentrated than conventional energy sources provide a good alternative in future rural development schemes. Their disadvantage lies in the fact that they are less mobile and of too low a grade to provide electricity for large scale consumptions.[51] Accordingly energy sources discussed includes solid fuels, oil and Natural gas, Uranium and Thorium, Biomass, Solar Energy and Wind Power.

Solid fuels: Solid fuels include coal, lignite, brown coal, peat, etc. The presence of coal and lignite in Ethiopia is widely reported, but since systematic exploration work has not been undertaken, it is difficult to speak of the quantity and quality of deposits available. According to a joint OAU/ECA report, recoverable resources but yet not under exploitation amount to 10 million tons of coal and 3 million tons of lignite.[52] The quality of lignite is reported to range in character from almost peat to sub-bituminous coal. Among areas cited as having potential for exploitation are "Gonder (Chelga) Wollo (Wuchale and east of Dessie), Shoa (Debre Berhan, Debre Libanos and Mugher Valley), Kaffa (Giren), Wollega (West of Nejo, Arjo), and Illubabor (near Urumu). From random samples it seems that the calorific value ranges from 1910 ÷ 6400 K cal/kg."[53]

Usurped of its role as the world's most important source of energy in and pre 1950 by the advent of cheap oil, coal has now found "a new lease of life" due to the increase in the price of oil. Not only is coal fast becoming economically more competetive, but is also opening additional prospect in the drive to attain self sufficiency in energy. Apart from its use as fuel, the use of coal in steel and chemical industries is also an additional factor for its importance. Though the success of liquification technology presently practiced in South Africa is relatively unknown and does not bring significant return, future development in this area is quite promising and in view of this, if the coal discoveries in Ethiopia turn out to be substantial there is no reason why one cannot envisage such liquification plants and the concomitant gains in the years to come.

Oil and Natural Gas - Eventhough oil seepages had been noted for a long time and exploration rights were granted as far back as 1945 and various exploration works have been undertaken, to date there is no crude oil or natural gas production in Ethiopia. The number of encouraging results found however give one hope for a possible strike.

> "Oil seepages were recognized at seven places on the Red Sea coast area and at four places in the Ogadan area. Out of 35 exploration bore-holes drilled 16 bore holes showed an indication of oil and gas. Trip or connection gas were encountered at various depths of different formations. ... The conclusion reached so far is that the Tertiary sediments of the Red Sea Coastal Area and the Harar Area are possible production areas. Some exploratory holes were drilled which led to some positive results but no exact estimates of deposities and flow characteristics are available." 54

Natural gas has already been discovered in the Ogadan. Though too early and apparently an under estimation , the OAU/ECA report puts Ethiopia's natural gas estimate at 55,944 tons of carbon equivalent.[55]

The long distance from Assab (over 600 miles) and the relatively small amount discovered makes additional strike necessary before commencement of commercial exploitation.

The existence of otherforms of hydro-carbons like oil shale and bituminous sands is also indicated. Despite such high hopes for oil strike, there is not much to expect in the short run. Consideration the soaring cost of oil and the rate at which other developing countries are searching for oil deposits would lead one to conclude that in Ethiopia it is lagging and needs much vigourous effort in the future.

<u>Uranium and Throium</u> - Uranimm and throium are in theory the two radioactive raw materials that can be used in the nuclear industry. Though uranium occurrences are reported as being observed in many provinces, extensive search for radioactive materials is almost non-

existent save one location where detailed geological mapping and drilling is undertaken. The report by Courier is one that raises hopes. According to this magazine "the two ACP countries, Niger, and Gabon, produce practically all the uranium ore from the developing world (excluding China) and the Central African Republic, Ethiopia and Zaire have reserves."[56]

The very high technical and financial as well as the highly skilled manpower that the nuclear industry demands makes early realization of nuclear power projects in Ethiopia impossible. Nevertheless, given the risk that fossil fuels may run out one cannot rule out the future use of nuclear energy especially, with the development of small and medium reactors. With further development and safety considerations fear of radioactive pollution will hopefully be minimized enhancing its public acceptance.

Biomass - Hereunder we consider all combustible or fermentable materials of vegetable origin. The obvious examples are wood, charcoal, dung cakes, corn cobs etc. However, since the above sources release their energy not only on being burned directly like wood but also after chemical processing such fuels as ethenol, we will treat them under different subtopics fuel wood, liquid fuel from biomass and gaseous fuel from biomass (biogas).

Fuel Wood - The traditional energy sources of which fuel wood is most important, accounts for over 95% of Ethiopia's energy demand. Such high rate of consumption coupled with absence of rational utilization has led to the faster growth of demand over supply leading to fuel wood crisis. As the data survey related to Addis Ababa (constituting 3.5% of the total population) indicate 244,646 tonnes of fuel wood were used in 1979 and 288,000 tons in 1980 showing an annual increase of 17.7%[57]. The Energy Commission report further reveals that:

> "Assuming an average stocking density of 30m^3/hectare, the destruction of wood lands for the supply of 20,000,0000 metre cube of fuel wood per year is estimated to be about 700,000 hectares per year. The destruction of forests for the production of charcoal to urban areas only is equivalent to about 50,000 hectares of Accacia woodlands per year.
>
> The uncontrolled cutting of fire wood (20,000,000 m^3) in Ethiopia, and the consequent deforestation amounting to about 700,000 hectares is destroying the ecological balance of many areas causing environmental damage and climatic changes."[58]

Such rapid and reckless deforestation if not effectively checked would according to many estimates leave the country devoid of forest cover within 20 years time. Whereas 40% of the country was covered by forests a hundred years ago at present less than 4% of the land is believed to be under forest cover. Yet Ethiopia's fuel wood consumption is among the highest in Africa and would continue to be quite substantial in the years to came.[59]

The fact that the "oil crisis" come at a time when the traditional source of energy is in such crisis compounds the problem. The magnitude of the crisis of the latter type becomes immense and incalculable when one considers the problems of erosion, siltation, and deforestation that follow such rapid deforestation. Furthermore the move towards burning animal waste and crop residue estimated to be 11 million metric tons of coal equivalent in 1976 alone is of serious concern since it further deteriorates the soil condition by depriving the soil of valuable nutrients and organic conditioning materials.[60] The amount of nitrogen and phosphorus lost in this way is enormous. In the absence of the application of chemical fertilizers for the majority of the areas already suffering from erosion and of poor soil condition, such further soil impoverishment is bound to lead to desertification and consequent famine. A case in point is the Sahel region of Africa where the depletion of forests has become so great that to go more than 40 kilometers from towns in search of fuel wood has become necessary. According to studies made in 1976, "much of the Sahel region will be reduced to desert by the year 2000 unless drastic measures are taken to ensure the rational exploitation of the resource base".[61] The rate of desertification has continued and seems to increase with the increase in the urban population. As a result, for many major towns the local climate has changed, the soil damaged, and the level of the watertable lowered. In addition prices of fuel wood have risen rapidly to a level that the low income section of the population finds it difficult to afford, while considerable resources (manpower, lorries, carts, animals etc.) have to be used for wood supply which might be better allocated to agriculture.[62]

It is such concern for the long-term ecological and social factors that should alert us against the present reckless use of our scarce resource. The human and material costs to be borne in the future will be insurmountable (if they already are not) unless we take heed of the problems others are currently suffering from.

One can of course understand the dilemma that is being faced. Had CE been as cheap as it used to be, one would have envisaged a gradual move to such forms of energy. And in fact this was the trend followed by the developed countries of today. Not only did such a transition to CE enable them attain a higher level of productivity and welfare, but also to ease the pressure on the traditional sources, which they currently exploit for various industrial uses. Such is not the case for LDC's. For instance, "if all developing countries households now using traditional fuels were to switch to kerosene, developing countries' demand for oil would rise by 15 to 20 percent."[63] Such increase in oil consumption is of course the last thing they need today. Hence, despite the critical condition of the traditional sector the high cost of CE, the low purchasing power of the majority of the population, low cost of traditional energy in the rural sector (almost zero financial cost) etc., will dictate the use of fuel wood for a long time to come . Some estimates indicate that it is possible to meet African needs for "traditional as well as CE" (Sic) exploiting a forest covering 26 per cent of the continent, under a "reasonable assumption" of producing "10 tonnes of dry fire wood per hectare per year and average calorific value of 4,000 kilo calories per kilo of dry wood, with efficiency in use of 10 per cent."[64] This estimate can be reasonably extended to the Ethiopian condition. By all accounts, fuel wood will for some time to come continue to occupy a major portion of the country's overall energy balance. If so, the only way to cope up with the problem of supply is to undertake a massive afforestation programme, and to improve the efficiency with which wood and other fuels are burned. Most of all it is essential to promote awareness among rural communities by actively involving them in controlling and managing forest resources and committing them to its protection.

Liquid Fuel from Biomass

One area that is currently getting extensive publicity and attention is the production of ethly alocohol (ethanol) from hydro-carbon products or from biomass.[65] Biomass ethanol is presently seen as a major renewable energy source by many developing countries. While hydroelectric power is expected to provide a great potential for production of non liquid forms of energy, ethanol production based on domestic resource is seen as offering immediate prospect to partially substitute for petroleum products, by providing a premium liquid fuel. Given the indicated high share of transport in petroleum consumption and the fact that ethanol can directly substitute for a premium petroleum product, gasoline, the increased attention it attracts is understandable. If put to such use, ethanol is reported to have many advantages due to its many physical/chemical characteristics.

Ethanol can be used either as"gashol" i.e. mixed with gasoline up to a 20 per cent ratio or direct as a gasoline substitute. When used as a gasoline blend for internal combustion engine it is known to bring significant change in combustion efficiency, "octane rating and other engine performance characteristics such as starting, carboration and emissions."[66]

The use of ethanol as a gasoline blend has further advantage since it does not require any modification in the engines that use gasoline. Additional applications include: a) as boiler fuel to substitute for fuel oil or other fuels b) gasoline substitute, c) diseal substitute c) as chemical product or feedstock.

Three main types of biomass raw materials are indicated as major sources for ethanol production. These are: a) sugar bearing materials (such as sugar cane, molasses, sweet sorghum etc.) b) starches (such as cassava, corn, potatoes etc.) c) cellulose (such as wood, agricultural residues etc.). Of the three the former is more favoured on economic and technical grounds.[67]

Feasibility study in the production of ethanol from molasses in Ethiopia was contracted to the OY AIXO Ab company of Finland. The company has found the project as feasible and has submitted a draft final report proposing the establishment of ethanol plant. According to the study the ethanol plant is to be located at Wonji, and is to produce anhydrous alcohol from molasses available in the sugar estates. The study assumes the projected expansion of the sugar estates as well as the implementation of the Fincha sugar project with its estimated contribution of 20,000 and 30,000 k tons in 1986 and 1987 respectively.[68] The capacity of the plant is stated to be "75,000 litres per 24 hours; is assumed to work 333 days per year and to produce at full capacity utilization about 20,000 tons of alcohol."[69] Production is further assumed to start in 1983-84 and reach full capacity in 1987 with estimated total employment of 81 persons.

The consultants discuss three cases, namely base case, alternative one and alternative two, with total investment costs (excluding working capital) of 25.7, 32.7 and 37.35 of which the foreign exchange component is 20.45, 24.25 and 31.35 million birr respectively. Though alternative one is recommended by the consultants, neither the prsent value of net benefits nor the internal rate of return is calculated to estimate the profitability of the project as is commonly done. The Project Agency undertook the task and based on a number of different assumptions has produced internal rate of return (IRR) results ranging from 11.23% to 28.89%.[70]

Many countries have undertaken the study and implementation of ethanol production with countries like Brazil at the forefront. Though Brazil has used alcohol fuel since the 1930's is started diluting its petrol (with 20 per cent alcohol) after 1973 oil price increase. The move to produce cars with special engine that take 100 per cent alcohol however, came after the second oil shock. According to the Economist petrol engined cars "are being left in the show rooms... 60,000 alcohol powered cars are produced each month... In early 1980 there were only 1000 alcohol filling stations, now there are 3200", 500 being added to it each month.[71]

Such dramatic achievement of Brazil is however rather exceptional. According to a World Bank report the cost levels achieved in Brazil could only be attained by very few countries that have efficient manufacturing sector. Below are capital cost figures (excluding working capital which could be substantial) for three general groups of countries;

low cost countries (like Brazil), medium cost (like Thailand) and high cost (like Sudan, Ethiopia).

TABLE 5:- Estimated Installed Cost of 120,000 litres/day Plan (in late 1979 US $ million).

Type	Country Grouping	Low cost	Medium Cost	High Cost
Sugar Cane based	Installed Cost	7.6	79.5	14.3
Molasses based		6.1	7.6	11.4
Cossava/Corn		9.1	11.4	17.2

Source: World Bank, Alcohol Production from Biomass, September 1980, p.32.

The same report puts the optimum size for sugar cane or molasses based alcohol plant within the range of 120,000 to 240,000 litres per day. For Ethiopia the feasibility study indicates only 75,000 litres/day at full capacity.

Even for Brazil where reported success is highly publicized all is not well. Brazil shows 6 million tons of food defecit per year. According to Mrs. Melamade "the predicted increase in land under cultivation will not quite keep up with population growth let alone freeing land for alcohol production."[72] Thus even for Brazil competetive between fuel and food crop production seems to be well underway. As one writer aptly stated such competetion is manifested in "comp. etion between the affluent minority who own the worlds 375 million automobiles and the poorest segments of humanity for whom getting enough food to stay alive is already a struggle."[73]

Apart from ethanol, vegetable oil, eucalyptus oil etc. are also known to offer the possibility of substituting for petroleum. Experiment made by Mechanical Engineering Department of Addis Ababa University has demonstrated that a 45 horse power diesel engine can start and run just as well on vegetable oil (extracted from oil seeds like rape seed (gomenzer), sunflower (suf), niger seed (nug) and cotton seed obtained as it did on diesel fuel.[74] The result obtained is reported as highly encouraging, especially for development of agro-industrial activities, since farms could reduce their dependence on imported fuel by complementing their food production with cultivation of vegetable oil. It is stated that "the harvest of one hectare of sun flower may yield enough oil to run all farm operations starting from ploughing to mechanical harvesting on ten hectares of sunflower farm."[75]

Though the economics of ethanol production is complex ranging from quantifiable benefits like the financial rate of return to unquantifiable ones like the strategic considerations of self sufficiency in energy, it is an area which provides a good prospect to many countries, of course to varying degrees. In Ethiopia too it is a worthwhile venture, whose relevance is bound to increase with future increase of petroleum prices, and development of cost minimizing techniques of production.

One important caveat however, need to be made. Any large scale production of fuel crops would in time compete for the limited farm land with food crops. The resulting competition and trade off among agricultural resources for producing fuel or food grains, could be painful as well as sensitive socio-political issue. Moreover, experiences of many

African countries show that costs (say of ethanol production) are generally understimated (e.g.ignoring the opportunity cost of molasses export etc.) and therefore thorough study and calculation of cost/benefit ratio need to be done before any serious comittment is made.

Biogas

One other area that has currently become very popular and has attracted considerable interest of many developing countries is the potential use of biogas plants to provide fuel for rural villages. This process which is identical to marsh gas accuring in nature is the generation of gas through an aerobic decomposition of organic waste. Theoretically any organic waste containing carbon, hydrogen and oxygen with a certain amount of nitrogen can be made to decay in an oxygen-poor environment to generate biogas with "a fairly high heat content per volume, 600-700 B.t.u. per cubic foot or 22-26 jiga joules per cubic meter."[76]

Countries like India, China and Korea, and other East Asian countries have been experimenting with biogas plants for a number of years with varying degrees of success. The Chinese who started promoting the technology during the "Great Leap Forward" programme of 1958-1960 with reported success have built over seven million biogas digester, requiring about a quarter of average annual per capita rural income and of simple designs.[77]

Since the dung from one cow per day is estimated to produce gas equivalent in energy to a pint of petrol[78] generation of biogas can be successful in areas where there are many cattle and other domestic animals. As the experiences of China and India have shown the problem in bio-gas generation is more social in nature than technical. The problem is associated with the scale of operation. Large scale biogas systems which use cow dung of every member of the community has economies of scale in capital costs, has smaller heat losses, and requires less precision to improve efficiency than those based on family units. The problem is one of getting people to get their livestock in communal yards, of disposing waste in manners that lends itself to easy collection for use. As for those based on family units the problem is one of irregular quantity and quality of waste since it comes from a single household. In fact the success of the Chinese is to be found in their cultural practice of keeping livestock in communal yards, the traditional practice of preserving night soil for fertilizing soil etc. as much as it is of institutional mechanisms. "The gas has proved to be quite sufficient for lighting, heating, cooking and in fact even for light industries."[79] In fact a study made by Makhigani and Poole show that such large scale biogas systems "are economically competetive with costs of disel or central grid electricity generation in Third World villages."[80]

Additional advantage of biogas is that the residue can be used as a fertilizer. The process is infact believed to increase the fertilizer and soil conditioning value of animal dung and other organic wastes. The labour intensive character of large biogas plants could also provide substantial employment opportunity for the poor ie. dung collection, fertilizer distribution etc. The Chinese in fact enumerate "ten advantages of biogas" in their propaganda to promote biogas plants.[81]

Efforts to promote use of biogas plants in Ethiopia has relatively been very small compared to other countries. Recently increased attention is being given to it by the Energy Commission. "The MKC Development and Rehabiletation Board at Nazreth has produced a prototype which costs 1600 birr and has a payback period of 3½ years".[82] It is further reported that the costs indicated though not as cheap as those of the Chinese, are comparable to the Indian digesters. However, studies based on Indian experience have shown that family biogas plants have a negative net present value in both financial and economic terms.[83]

Despite the reported success of biogas here and there, there are many points that are dubious and not clear.[84] One thing is very clear though and it is the fact that success is to a considerable degree tied to organizational and institutional capacities. The tremendous advantage that the cooperationization programme in rural Ethiopia offers in bringing about such success is well noted. However, diffusion of biogas technology to rural Ethiopia will still face enormous educational, organizational and infrastructural tasks, especially when we consider the absence of public or even housed latrines to collect might soil, the scattered nature of rural houses, the competing use of cowdung in domestic fuel etc. before it becomes of wide use.[85] Emphasis again need to be put on the importance of social factors, which could prove crucial as the success of the Chinese and apparent failure of Indian efforts demonstrate, rather than technical aspects. Ethiopia's livestock population (27 million cattle, 6.7 million equines, 1 million camel etc.) reported to be the first on the continent as well as cooperative ventures in the rural area offer good ground to hope for future success. However, in the foreseable future, biogas plants seem viable only for producers cooperatives and settlement areas.

Solar Energy

Solar energy which is practically the source of all other forms of energy has also drawn immense interest both in terms of short and long range considerations of the world's energy needs. The fact that it is free, inexhaustible, clean and abundant makes it very attractive. It however took the soaring prices of oil to spur the interest of governments and scientists alike to work industriously to develop effective means of using solar radiation.

The possibility that solar energy offers in meeting man's future energy demand is quite enormous. According to some estimates "a surface of 1,000 square meters under the sun... receives at noon solar energy equivalent to the energy of 40 average tractors."[86] Here is another illustration. During a sunny day "the roof of a building 10 meters square receives some 500,000 kilocalories or the amount of energy produced by the combustion of ... 55 litres of petrol."[87]

The extent to which solar energy could contribute to Ethiopia's energy need is not known. The potential importance of solar energy varies in accordance with the climatic zone. Although consideration of the quite significant solar insolation that the 1.25 million square kilometer of the country's land surface receives could lead one to conjecture the substantial contribution which it could have - especially for the rural sector - increased knowledge of solar potential through improved and more extensive measurement and monitoring is necessary before one can meaningfully talk of its significance in the country's economic and social development. The need for collecting solar energy data must be seen in light of this.

Although R & D is still necessary in concentrating, collecting and storing sunshine for wider application, already a number of uses (some requiring more attention than others) are cited for possible use in countries like Ethiopia. These are water heating, cooking, cooling, and power generation as well as photovoltaic cells to convert sunlight directly to electricity.

Given the very high (ranging from 80 to 90 per cent) share that heating and cooking takes of household energy needs in Ethiopia, the enormous contribution that it could make in easing the pressure that is put on traditional energy sources like fuel wood cannot be over emphasized. Studies made in countries like Egypt have shown that solar heating is less expensive than heating with kerosene, butane gas or electricity.[88] Other uses include solar drying, solar distillation, water pumping, etc. The designing of effective solar crop drying methods is of special importance since it could help overcome the harvest losses which in Ethiopia are estimated to be more than 25 per cent of yields.[89] In contrast to open air drying which in many cases could be damaging due to rain, wind or animals, controlled drying in enclosed space offers more secure and for perishable products like fish, tobacco, coffee, fruit etc. more appropriate means.

A solar thermodynamic station established in Dire, Mali with rated capacity of 65 kw beautifully summarizes its contribution:

"- pumping an average 600 m^3 of water daily from a borehole to supply Dire village with drinking water
- Running a refrigeration unit producing 30,000 negative kilo calories daily to maintain a temperature of 4°c for the conservation of perishable foods
- Supplying an average 5 kwh of electricity daily for evening lighting.
- Generating an average of 450 kwh daily."[90]

Due to the high cost of investment required such multipurpose stations are for now exceptional. But with the development of better devices and diffusion of the technology, wider application in the near future can justifiably be expected. Despite the problem of cost, their promise of long life and relatively easy operations make photovoltaic cells quite attractive for rural economies. Cost of photovoltaic electricity is falling rapidly and may continue to do so with improved technology, offering quite a promising future. In fact "it is forecast that the price of solar module will drop from 13 dollars (the price in February 1970) to about 50 cents by 1985 and to 15 cents in 1988".[91]

Experience on the use of solar energy in Ethiopia at present is very scanty. Efforts are however underway by the Science and Technology Commission to develop and diffuse such solar devices for cooking, drying etc.

In general, increased R & D is required before solar energy becomes of wide use both in the developed and developing countries alike.

Wind Power

Being a form of solar energy, wind power (acolian energy) is a non-polluting, inexaustible and very cheap form of energy, once the initial investment is made. The major disadvantage lies in the fact that it is highly irregular in terms of time and place and storage is rendered difficult during periods of calm.

Windmills have been in use since ancient times, and with the advent of the energy crisis interest in them has increased in some and revived in other areas. Applications in the past consisted mainly in the field of water pumping and grain grinding. The coming of wind driven electric generators (available now commercially) has enabled diverse use of it.

Winds in the tropics are not as stormy as those at higher latitudes. As a result the use of wind power in countries like Ethiopia is not as favourable as that of solar energy. Nevertheless, there are certain areas where its use is practical and could offer, at least a practical solution to the country's energy problem. Integrated use in conjunction with equipment and machines powered by other renewable forms of energy (discussed above) could further enhance its contribution. Reports indicate success of numerous experiements carried in Africa. To cite a few cases:

"In Ethiopia, an original type of windmill has been developed with very good performances. In Kenya a windmill has been installed ... for demonstration purposes ... In Mauritania, an aerogenerator has been installed.... with a rated power of 1 kilowatt... In the Sudan, about 250 units have been installed in Gezira province for water pumping."[92]

Despite such endeavours, "wind parameters are still poorly known in Africa. Metereological data usually include only the ground-level wind velocity and give only qualitative information so that quantitative measurements of 50-100 meters are (hence) called for."[93]

The problem is further aggravated by the fact that wind energy parameters are particular to each site and thus create the need to always study metereological data and make a series of measurements. In Ethiopia, such study is very scanty and those available in some stations were done "for the exclusive use in metereological services by the Civil Aviation Administration... However wind and solar radiation data known as "N Summary" are also available for some locations in Ethiopia, on computer tapes and/or in computer read out forms at the National Climatic Center in Asheville, North Carolin ."[94] It is our hope that best use of existing data will be made and further prospecting for suitable sites and measurements will be made.

As a concluding remark to this chapter, we would like to add that none of the energy sources cited could solely lead us to our strategic goal of self-sufficiency in energy, but rather the composite exploitation of all available energy resources. It is in this light that we should approach the issues of shifting towards indigenous energy sources.

5.0 Energy, Technology and Development

Soaring import bills have dealt a giant hammer blow to the development programme of LDC's. Energy is no more a cheap input. It is now as equally important and decisive as factors like capital and skilled manpower. If so, any development plan that does not take it as a central element in its exercise cannot be worth the paper it is written on. In fact its importance for LDC's is so great that at least in the short run, it will be the factor that will influence the development strategy to be followed.

Prevailing situations do not allow LDC's to imitate the development pattern followed by the industrialized countries. Today's developed countries had colonies to exploit, a very wide external market for their produce, and above all had cheap raw material and labour force to boost their economic growth. The base of their developed economy, was laid by the blood and tears of millions of African, Asian and Latin American people. As Marx aptly remarked a hundred years back it was

> the discovery of gold and silver in America, the extirpation, enslavement and entombment in mines of the aboriginal population, the beginning of the conquest and looting of East Indies, the turning of Africa into a warren for the commercial hunting of black skins / that/ signalized the rosy dawn of the era of the capitalist production.[1]

Less developed countries on the other hand face monopolized foreign markets, excessively high prices for imports of capital goods, low price for their export items etc. and currently weaknesses of import growth in the industrial nations as a result of the slow down in economic activity in the latter. The increase in the price of oil thus threw them from the frying pan to the fire. Apart from its direct effect of increasing import bills such a price rise has contributed to cost push elements to inflation, which in turn has also led to the indirect effect of increasing the cost of imports of industrial goods. What makes the situation even more serious is the fact that economic activities in these countries are highly responsive to many influences of domestic origin such as weather, natural calamities, political upheavals, etc.

The present consumption pattern of developed countries is not one that developing countries could follow either. It neither is possible nor desirable. The high population growth rate, the relative scarcity of raw materials, etc. prevent such an extravagant pattern of consumption.

In light of all these factors, therefore, developing countries will have to follow (adopt) a different development strategy. Especially, the present high cost of energy would call for a development pattern that is less energy intensive and more efficient in its utilization. This brings us to the issue of appropriate technology which upto now mostly assessed the problem from the premises of scarce capital. Today concern for optimal utilization of energy will figure equally (if not more) important as that of capital in this currently very popular issue of appropriate technology.

The importance of technology in economic growth and development is very well noted. Until the issue of energy relatively overshadowed lack of modern technology, dependence on the developed countries for the latter was seen as the basic constraint for the development of LDC's. It was argued that of the three factors of production traditionally held as determinants of production (land, labour, capital) these countries lack neither land nor labour but capital and its counterpart technology. Oil crisis has now brought additional dimension to the problem since modern technologies are not only capital intensive but are also energy intensive. The dependence of production upon available energy is moreover greatly felt in the field of C.E. because it is for these type of energy sources that modern equipment and technologies create a rising demand. In addition, not only does CE meet the increasing demand of households whose growing use of modern appliances for heating, cooking, lightening etc. need such forms but also replacement of artisan by modern factories create even larger demand leading to the replacement of animate form of energy and vegetable fuels.

Advanced technologies have generally been considered as inappropriate both from the point of view of resource utilization (its capital intensive character)and availability of market (an issue closely related to capacity utilization). Leaving the details aside the energy intensive and labor displacing character of modern technologies seriously undermines the widely held development strategy which implicitly holds rural underemployment as a potential for urban based economic growth. The question now (at least in the foreseable future) is not to provide labor to support the growth of the modern-urban sector by outmigration, but rather that of finding a way to keep it in the rural sector. In order to provide the surplus labor which is underemployed in agriculture with gainful employment it therefore, becomes necessary to promote the development of small scale industries and decentralized and renewable energy sources on which they are to be based. Advanatages of such small scale process could be summarized as follows: they use local materials wherever possible, involve decentralized energy sources such as wind power, water power, biogas, solar energy, animal or human generated mechanical power, create more jobs employing local skills and labour, are small enough in scale to be within the means of rural cooperatives, contribute to regional distribution of industries, can be understood and controlled by villagers without a high level of education, makes technology understandable to the masses, have minimal foreign exchange requiremt, do not involve patents, royalties, consultation fees; its need for a pre-existing well developed infrastructure is minimal; can efficiently utilize the patches of raw materials that are landlocked in the interior due to lack or high cost of transport, can contribute towards easing urban congestion, enhances monetization of the economy etc. - all of which have direct or indirect effect in easing the energy problem[2]

To dwell more on the point of interest, the decentralized energy basis cited can help run various kinds of small-scale industries. For instance small scale industries suggested as suitable for using biogas include "cement production in vertical shaft kilns, artisian and pottery crafts using new foundry and glazing techniques available with gas , and even small scale chemical and metallurgical industries which use natural gas processes."[3]

Such orientation in favour of small scale industries does not necessarily imply exclusion of all large scale projects. Their importance as spearheads for development is well noted, and many of them (heavy chemicals, iron and steel, oil refinery etc.) allow us no choice other than capital and energy intensive methods. What it therefore means is that in light of the energy problem whenever possible and found advantageous efforts should be made to move away from energy intensive methods of production, that the development strategy to be followed should dictate the orientation of energy development projects in agriculture, industry, etc. in the rural sector rather than large scale urban based industrialization whose foreign exchange and centralized energy requirement is very high. It should be noted that the choice of technology and consequently the energy form to be used ultimately depends on the choice of development strategy to be pursued. "Once the relative importance of the various economic social and temporal goals have been specified, and once the relative contributions of the different sectors and the relative benefits to the different participants" is determined, then the technology (and the corresponding energy form to be employed) is largely set.[4]

The theme underlying our discussion is that there is a dialectical unity between the availability of the different forms of energy, the development strategy to be followed, and the technology to be employed and that such compatibility has to carefully be heeded if the country's development prospect is not to be jeopardized.

Another very important point that needs immediate attention is the need to undertake collective R & D by developing countries be it on international, regional or subregional basis. Past experience had amply demonstrated that industrialized countries develop technologies that respond to their problems, make use of their abundant resource and capabilities. In the absence of alternative technologies that are more in tune to their needs developing countries would be forced to blindly follow the developed countries as they shift from one to another form of energy. Fore example despite the abundance of hydro-power in many developing countries the shift made by many developed countries from their relatively small hydropower resource to the then cheap and largely unexploited petroleum was simply followed by poor countries, leaving them as it is saddled to serious energy problem. Similarly the present trend of shifting to nuclear energy may also necessitate similar shift (with all the problems) unless they urgently undertake collective R & D to come up with technologies that take relative abundance and availability of different forms of energy into account. While monitoring of the transfer of technology, assessing its impact, absorption and possible adaptation may help in the short run, the long run solution could only be developing ones own technological capability by investing on collective R & D.

Unfortunately R & D in LDC's lack proper orientation and generally operate as satelites to R & D system of the industrialized countries. As Amilcar Herera remarked, the population of LDC's is divided into "an urban consuming portion, whose values and needs are those of the industrialized societies and a rural producing portion whose traditional values and needs remain ignored."[5] As a result the R. to D system operates from the urban milieu.. thus becoming sensitive to the problems as seen by the industrialized societies,"[6] which we feel is one of the major reasons for the apparent lack of success.

The close relationship between the product produced and technology employed - and consequently the amount and form of energy required would also necessitate the inclusion of product planning into our development strategy. Products that are manufactured in developed countries are the fruits of technical innovations there. They are produced to satisfy the need of a highly sophisticated and rich people with different culture and environment. Such products therefore,

> tend in many cases to have characteristics unnecessary to developing countries as well as requiring complex and capital intensive methods of production. Nylon shirts, for example, are not essential for adequate clothing in a very poor country and indeed probably very uncomfortable in the heat.[7]

The question here therefore is not only of choosing a technique from a range of available technologies to produce a particular product, it is also a question of choosing what products to produce. For instance, "all building materials from mud to reinforced concrete or fibre glass contribute to the need for housing - (however) bricks capable of sustaining a seventeen storey building may be excess standard or overkill if used for single storey accommodation."[8]

Obviously the technology required in making the different materials (mud, concrete, glass) or some material of different qualities (brick) is different having different implication on the form and amount of energy required. This means the questiom of technology - and the form of energy required -- appears both on the supply side (the technology to produce with) and the demand side (the products to be produced). Hence on the supply side rather than putting unabated pressure on urban industries, developing small scale industries around the activities of blacksmiths, weavers, tailors, carpenters, masons etc. that use decentralized energy sources could help contribute to meet the growing demand of the rural population, as well as easing the problem of energy. This would among other things require devoting resources like R & D to selectively upgrade the technologies which are used to manufacture the older traditional products. On the demand side this would require limiting imports of certain competing products, combating the unhealthy trend of the rural sectors changing pattern of consumption -- i.e. a copy of urban taste pattern, itself a replica of metropolitan countries. Simultaneously it is important to provide technical assistance to traditional producers in making better designs and quality, in adapting their product to modern taste and living conditions.

In short, such concern would in the short run call for developing decentralized energy sources, encouraging small scale industries and increasing energy efficiency of large scale industries, Such a move would enable quick recovery from the external shock that they we suffer from and carefully plan our future energy consumption in line with our need and potentiality.

Sector wise, transport poses formidable problems, Transport being the sinews of a country's socio-economic setup, anything that adversely affects it will inevitably affect every facet of economic life. As one writer remarked, with the development of fast and efficient modes of transportation the world has come to be a small village. Increased cost of transport as a result of oil price increase however, seems to relatively reverse the process by increasing the "Friction of distance", In other words, "in transportation space terms (which is a relative measure of space), the relative location of place has (now) changed. Space has expanded, which means places are further apart," and consequently are less accessable. As a result the spatial behavior of people and their perception of space is bound to change leading to less interaction and relative isolation.[9] Though not pursued here the resulting effect on socio - economic development is on that merits a detailed study.

As it is, the large majority of the population lives more than a day's or two's journey on foot from main roads and that very few places are really accessible. If the few accessible areas now become relatively far apart, the adverse socio - economic problem that could follow is not difficult to imagine. Not only would diffusion of innovations, but the whole effort of pulling the dominantly subsistence production of the rural population towards surplus production and monetization would also suffer significantly, unless farmers could sell their surplus production, they would lack incentive to prduce more. Given the interdependence of the industrial and the agricultural sectors (in market, supply of inputs etc.) the resulting wedge between the two and the consequent slowing down of general economic activity is bound to be determintal to economic growth. One therefore, faces the dilemma between choosing high cost yet "efficient" carriers like cars, railways etc., or low cost but "inefficient" modes like pack animals. Actually the problem is not that clear cut, nor the solution so unique. Composite measures involving trade offs between cost and benefit will be essential.

Since problems and prospects regarding modern modes of transport have been discussed in the foregoing chapters, (see section 4.2.2), we will briefly comment on the traditional modes. Pack animals have for centuries fullfilled the role of transporting goods and despite their "inefficiency" compared to modern modes, their contribution (estimated at 500 GWH annually)[10] is far from declining, least of all in the present era of high energy cost. Thus ways and means of making them relatively more efficient and convenient carriers should be sought, especially for the rural sector. Widescale introduction of mule, donkey etc. drawn carts is one example. In short, in order to satisfy transport and energy requirements at minimum cost it is important to realize that different modes have very different energy requirements, just as the different forms in which energy is used constitutes different transport implications.

Future consideration necessitates careful assessment of the agricultural sectors CE requirement. The Green Revolution during the 60'sand 70'shas to a varying degree locked many developing countries into dependencies of energy intensive agriculture - fossil fuels, chemical fertilizers, pesticides etc. Though of relatively small significance compared to such countries as India, intensive farming in Ethiopia also began during this period. Now that energy is expensive, intensive farming is nomore as "rewarding as before," despite its high yield.

At least short run considerations dictates judicious use of CE and making intensive use of our abundant labor and animal power and to the extent possible engage in extensive farming.

Though it would be a bit difficult and involved to give any explicit suggestion with respect to state farms, consideration of scarce capital, high energy cost, supply of spare parts, lack of know how and infrastructure etc. definitely calls against encouraging large scale mechanization of peasant agriculture. Emphasis should rather be put on raising the productivity of the existing small scale labor intensive agriculture. This can be done by modernizing indigenous techniques through local manufactuing of hand tools, animal drawn implements, simple hand operated or simple power agricultural machines. The contribution of the 6 million or so heads of drought animals in the country (with estimated 1180 GWH yearly outpu)[11] should not be overlooked.

Nevertheless it is crucial to note that even if such a strategy could considerably reduce the otherwise unbearable burden that could result if present pattern of development is maintained, consideration for increased productivity to constantly raise the standard of living of the people would in the long run call for increased utilization of CEC. For one thing in view of the urgency of development, developing countries have less scope for reducing consumption of CE than more advanced nations. For another, although energy policies could contribute to a gradual shift in production modes towards a greater degree of labor intensity which may allow reduction in the growth rate of CEC, in the long run (however distant that may be) -- higher level of development would inevitably require large scale industrialization and mechanization of agriculture which would obviously be energy intensive. In fact it would be impossible to imagine successful socialist construction without abundant use of CE and the concomitant productivity to be attained. Apparently Lenin had this in mind when he defined socialism as "Soviet power plus electification!"

In the long run increased move towards energy intensive activities is unavoidable. Sooner or later development would entail replacement of handicrafts and small scale industries by large scale production, peasant agriculture with tractors, pack animals with lorries etc. Increased standard of living would als lead to gradual substitution of traditional and animate forms of energy by CE sources. If so energy measure that enable quicker and greater exploitation of our energy potential should urgently be undertaken. To repeat what was said earlier in the beginning, Energy, – CE in particular – is a sin-qua-non for development. Self sufficiency in energy as a strategic goal should therefore attract priority attention!

6. Conclusion

Although always recognized as a need, energy has customarily been regarded a low cost, widely available resource. As a result energy efficiency consideration was not given its due importance both in its use for direct consumption and for production. The 1973-74 price increase of oil has changed all that. Energy-in its most widely used form-petroleum,is today a very expensive commodity and is likely to remain so while its supply continues to be a much decisive a factor in economic development. It's special significance to the country's development effort rests on the expression of the following findings of the study:

a. Though small in quantity consumed (4% of total energy), CE is strongly and positively related to GDP as well as the various portions of GDP except the agricultural portion of GDP which comprises largely subsistence level, peasant agriculture whose needs for CE is minimal.

b. The high rate of oil price increase has had a marked effect in worsening the country's balance of payment position and the level of inflation rate. Though found difficult to isolated the extent of its adverse effect, (from similar effects caused by non-economic factors like drought, war etc.) the series of price increases have contributed to the deterioration of the country's economic performance.

c. The price inelasticity shown by CE demand (reflecting the absence of substitution and technological rigidity) coupled with the strong relationship it has with GDP indicate that LF import will claim a fast growing share of foreign exchanging earnings reaching unmanageable proportions within the next few years. (see projections made- Table 3.3.2 and 3.3.4).

In short the strength and rigidity of the relationship between economic development and CEC (indicated in the study) gives a special dimension to the implication that the steeply up-ward trend of petroleum price could have on the development of poorer countries like ours. In the most immediate sense rising petroleum prices have meant a fast and sustained worsening of balance of payment position with obvious implications to growth possibilities. What is more alarming and ominous is, however, the grave difficulty that the country could face in the very near future, if the present unhealthy trend is allowed to continue.

It is a conclusion of this study that the absence of a comperhensive and consistent energy policy and unsound use of disparate price and fiscal instruments have also contributed to the problem. It is high time that a well founded comprehensive energy policy be designed and implemented to cope with the problem. Recognition of the following should be the starting point for prospective efforts in that direction.

a. The country's excessive dependence on imported fuel which at present is absorbing an increasing share of its meagre foreign exchange earnings, resulting in balance of payments problems, and the equally important political dependence that it is likely to ential.

b. The high financial resources, especially foreign exchange, that the exploitation of potential resources require due to their capital intensive nature, often aggravated by the remoteness of potential sources from main economic center.

c. The grave situation that the traditional energy is in and the need to undertake immediate and vigorous conservation measures as well as to step up the afforestation programme.

d. The relatively inefficient use of CE in the face of increasing demand both for development and direct energy consumption.

e. The country's declared objective for undertaking socialist construction and the need to meet the very high energy demand that goes with it.

Attempts are made to state the problems and the policies to be designed for solving them. It would of course be presumptous for us to indicate all the possible solutions or even those considered best. As we tried to point out in the text there could be no unique solution but rather a broad spectum of possible measures ranging from the relatively painless to some requiring the undergoing of a period of relative hardship. Broadly speaking these range from expanding domestic energy resources to making efficient use of those imported. The former demands closer attention on the part of government by way of allocating enough fund (that it deserves) for exploration and R & D, as well as providing the necessary incentive, legislation etc., judicious utilization of price and fiscal instruments etc.

While the latter requires responsible and understanding attitude on the part of all consumers of energy. The following are some of the possible measures put in time perspective. We would like to point out that our categorization of the measures indicated (into short and long term) doesnot involve any precise delimitation and simply reflects a rough picture of the time dimension involved.

Short Term: (including immediate measures)

a. To make sure that relative prices and tax policy for the various energy forms adequately reflects their opportunity cost.

b. To divert the resources spent on subsidizing CE consumers towards measures that countribute to end use efficiency and enhance supply possiblities. (see appendix 4f) .

c. To undertake vigorous and urgent conservation measures to combat wasteful practices, to check the unhealthy trend in comsumption pattern (especially in transport and particularly that of government-administrative consumption). The measures would among other things require:

i. finding causes of low efficiency and duly taking corrective measures, introducing energy saving devices etc. For example in road transport this can be attained by way of improving maintainance, management, road conditions, switching to more fuel efficient cars (e.g. smaller cars, diesel than gasoline trucks) etc. In industry simple improvments in production processes like better bearings, better insulation,retrofitting etc can contribute to such end. (see appendix 4d and 4g).

ii. trainning people engaged in production and consumption of energy as well as educating the general public on the importance of conserving energy, on ways and methods of attaining good energy saving practices and on the availability of alternative technologies etc.

d. To develop organizational means of selecting, monitoring and diffusing technologies that are efficient in energy utilization or better still those that employ more of domestic energy sources.

e. To discourage the construction of new and exclusively oil fired power stations.

f. To improve refinery and distribution so as to reduce cost to final consumers.

g. To urgently undertake the inventory of the country's energy resources, along with the ranking of such resources according to the ease and possiblity of their exploitation.

Medium term measures

a. To explore substituation possibilities between energy forms in view of making gradual move towards energy forms deemed advantageous to the country. This is closely tied to the selection of technologies that employ such energy forms.

b. To undertake vigorous afforestation programme with a view to creating a comfortable margin between regeneration and off-take rates. This would among other things require the allocation of adequate fund and trained personnel on the part of the government.

In view of its importance (social, economic and enviromental) we hold that the present effort is inadequate and that the much publicized planting of trees largely by inexperienced and non-committed people involves a serious and costly mistake, especially when one considers the small rate of plants that strike root and consequently the resource, and inview of the vrgency the valuable time lost.

c. To develop R & D capacity especially in the development of new and renewable energy resources and technologies that employ them.

d. To promote development of small scale industries based on decentralized energy sources. (see appendix 5a).

e. To convert existing oil fired power stations to hydro-power or linking such thermo-electric stations with hydro stations.

f. To make wide use of such domestic energy source as geothermal and hydro-power.

Long term measures

a. To undertake town and industrial planning in light of efficiently utilizing energy resources

b. To shift traffic from less to more efficient carriers. For example establishing electrified trolley buses or trams for major cities like Addis Ababa and rail links between major activity areas.

c. To undertake investment in large scale energy projects that lead to the strategic goal of self sufficiency in energy and rural electrification schemes. It would be worth while to note in this context that the World Bank gives financial assistance and has lending program for energy development. It is therefore very important to explore this and other possibilites and take advantage of it.

d. To develop regional cooperation for joint exploitation of energy resources as well as undertaking joint R & D

These in short are some of the measures that should be taken to overcome the energy problem. If with all due haste the measures suggested are undertaken the future may not be as bleak as the paper has so far tried to sound.

Notes to Chapter One

[1]Development and Cooperation, (Bonn, German Foundation for International Development, No. 3, 1981), P. 3.

Statement made by FAO Director General clearly shows the extent to which high energy cost has pushed LDC's to the brink of disaster. He said, "as a consequence of the sharp rises in energy cost, already 600 million people in the would are estimated to be in immediate danger. Rector Seodijafmako of the UN University goes further in showing "the synergetic effect of the food and energy crisis." He underscores the fact that "LDC's cannot solve their food problem without solving their energy problem." (The UN University Newsletter, Vol. 5, No. 2, May, 1980).

[2]Michael Tanzer, The Energy Crises: World Struggle For Power and Wealth, (New York: Monthly Review Press), P. 54.

[3] Alberto O. Hirshman, The Strategy of Economic Development, (London: Yale University Press, 1958), P.V.

Notes to Chapter Two

[1]G.H. Daniel and E.A.G. Robinson, "Planning of Investment in Fuel and Power in LDC's.", World Rpower Conference, (Belgrade, / n /, 1957), P.3.

[2]For the list of countries see appendix 2a.

[3]Johan G. Leigh et al., Energy and Development: A Preliminary Analysis for Less Developed Countries, (Mclean: The Mitre Corporation, July, 1979) PP. Xi - Xii .

Models tested are

$$Y = B_o + B_i X_i$$

$$Y = B_o X_i B_i \qquad i = 1,2$$

Where for the different runs the dependent variables were GNP/Cap, agricultural and industrial portions of GNP/Cap. The independent variables are Gross Domestic Investment per capita(GDI/Cap) and CEC/Cap. For the additive model, the rates of growth of the variables indicated were also taken as a second alternative.

[4]bid;, P. Xii

[5]Similar studies includes, J. Darmstadter et al. Energy in the World Economy, Resources for the Future, 1971; A Lambertini, Energy and Petroleum in Non-OPEC Developing Countries 1974-1980,World Bank, 1976; B.J. Choe, Energy Consumption in Developing Countries, World Bank, 1979.etc.

[6]United Nations, "Energy in Latin America" Economic Bulletien for Latin America, (New York /n.p/, 1971), et. Passim.

__________ "Energy Consumption in Latin America" Economic Bulletien (Santiago: 1956).

[7]Leigh, PP. 55 - 78.

[8]For the data base see appendix 2b

[9]The strong relationship between CEC and GDP further confirms our hypothesis that though small in magnitude, CEC is largely used for production purposes, while the traditional energy, though constituting the bulk of total energy consumption is used for cooking, heating etc. (subsistence level).

[10]At first attempt was made without lag. The negative relationship obtained with GDP/Cap led us to attempt a one year lag. Marginal improvement was found with regard to GDP/Cap, but no significant change was observed with respect to the other variables. We feel that knowledge of the lag period considered as appropriate (a point not central to our study and hence not pursued) could improve on the results obtained.

[11]Coerrelation between CEC/Cap and GDI/Cap was computed to see whether multicolinearity between the two could have led to the absence of significant relationship with GDP/Cap. The result obtained ($r = -0.12$) however, suggested otherwise.

[12]Considering the low monetary investment allocated to the sector in the past, the strong reltionship found may at first seem strange. However, the result would be plausible when one considers the substantial amount of non-monetary investment (i.e. in kind), largely agricultural included in GDI.

[13]In the belief that a better picture of investment in the industrial sector would be obtained if the contribution of small scale industries is excluded, regression of industry "proper" on Ct and It-1 was made. The result obtained confirmed our contention.

$$Yind = 2.51 + 0.37C_t + 0.24I_{t-1}$$
$$(0.035) \quad (0.041)$$
$$R^2 = 0.92 \qquad F \text{ statistic} = 73.0$$

Since investments in small scale industries are not well recorded, we feel that its exclusion is proper. The following log linear model was also tested, and the result obtained was similar.

$$Y_t = B_o \, C_t^{B_1} I_{t-1}^{B_2}$$

../3

[14] Development and Cooperation: Vol. 3, 1981, P.5

[15] At first 3 years were used (i.e. including 1979) for the analysis. Closer examination, however, revealed the 1979 data to be highly inconsistent. For instance, while GDP/Cap for Ivory Coast and Nigeria increased by 51% and 60% respectively (over the two year period - 1977 to 1979), their CEC/Cap decreased by 34% and 22% respectively. Again for Zambia CEC increased by 78% a phenomenon experienced by non of the remaining countries, or by the same country at earlier periods. Such anomaly led to the deletion of 1979 from consideration. For the data, see appendix 2c.

[16] World Bank, World Development Report, August, 1980, For the list of countries see appendix 2d.

[17] United Nations, Economic Bulletien for Latin America, (Santiago: September, 1956), P. 41.

[18] The Beijir Institute; Policy Issues in Ethiopian Energy Development, (Addis Ababa: May 1981), P. 13.

[19] Leigh, P. Xii.

[20] The Economist, (June 1981), P. 58.

[21] Ibid., (20 - 26 March, 1982), P. 99.

[22] Except for 1973, it has been showing defecit for over 20 years. See appendix 2e.

[23] See appendix 2f.

[24] See appendix 2e.

[25] Ibid.

[26] See appendix 2g.

[27] For the explanation of the growth rate used (5.3%) see section 3.3.

[28] Beijir, P. 15.

[29] National Bank of Ethiopia, Quarterly Bulletiens, Economic Research and Planning Division Addis Ababa Issues 1977,1978,1979,1980,1981.

[30] The Economist, (March 1982), P. 99.
Ethiopias low external indebtedness does offer the possibility, but as indicated the high cost of borrowing is not encouraging.

[31] Leigh, P. 34.

[32] The assumption is that given the established relationship between CEC/cap and GDP/Cap, reduction in the absolute level of LFC or of decline in the level of investment (presumably due to high share of foreign exchange that fuel import claims) would show significant relationship, or would have marked effect on the GDP growth rate.

[33] Energy intensity is defined as amount of CE per unit of GDP, i.e. birr/kgce.

[34] Leigh, P. 39.
It is also indicated that over that same period (1973-77) the industrialized countries experienced a rise in inflation (from about 7% to 11%).

[35] For the data base see appendix 2f.

[36] Similar result was obtained by using value of crude oil imports adjusted for quantity variation over the period as independent variable.

[37] Time, April 19, 1982, P. 38.

[38] NBE, Quarterly Bulletien, Vol. 6, No. 2, June 1980, P. 59.
N.B. Money supply is taken as currency outside banks and demand deposites.

[39] CSO, Statistical Abstract, Addis Ababa: 1976, P. 152.

NOTES TO CHAPTER 3

[1]Economic Commission for Africa, "Report of the Technical Panel of Experts on Hydro- Power," (October 20-24,1980), P.8 et Passim, (mimeographed)

[2]See appendix 3a

[3] E.C.A., October 27,1980,p.8

[4]Ibid

[5]Towns like Hagre Hiwot use deisel generators though situated along the path of the main transmission line from Fincha. It is largely because they were not taken into consideration during the stage of project design that a number of such towns do not enjoy the advantage of hydro stations.

[6]E.C.A., October 20-24,1980,p.6.

[7]See appendix 3b

[8]E.C.A.," Study on Electrical Energy Development in Ethiopia", (Addis Ababa: December 1980),P.7. (mimeographed)

N.B. Societa Eletrica Dell' Africa Orientale (SEDAO) with installed capacity of 8 M.W.used to provide electricity for the Eriterea region until it was incorporated with EELPA.

[9]For the list of stations see appendix 3c

[10]E.C.A., December, 1980,p.23

The writer has come to know that this same view is shared by some EELPA staff as well. Currently study is underway in two places-Melka Wakana and Gilgel Kibe to agument the capacity of I.C.S. The former is undertaken by The Soviet Government while the latter is by the Italians. It is believed that it will take 6-8- years before any of them become operational. Tiss Abay is also under study to agument The Bahr Dar capacity, and to extend supply to Gondar-Dejen. Transmission lines are bieng laid.

[11]Beijir,p.15

See appendix 3d and 3e for electric power requirement for new public industrial projects and forecast of power consumption for the next 10 years respectively.

[12]E.C.A., October 27,1980,p.6

[13]See appendix 3f

[14]OAU/ECA,"Energy Resources in Africa",(Addis Ababa:24-28 March 1980),pp.123-124, (Mimeographed)

15
E.C.A., December, 1980, p.5

16
Ibid

17
Ibid, p.6 et passim.

18
OAU/ECA, p.233

19
See appendix 3g.

20
Light products consist mainly(petro land kerosine) and are relatively used as consumer goods whith the heavy products (diesel and fuel oil) are more used in productive industrial and agricultural activities, diesel for farm engines and for small scale thermo electric stations, banker furnace etc.

21
See appendix 3h.

22
World Bank, "Energy in the Developing Countries,"p.22.

23
Ibid, p.24

N.B Ethiopia's re-export of such item reached a record high of 220,000 tonnes in 1980.(source-EPC)

24
The World Bank, p.24

25
Transportation and distribution of petroleum products is undertaken by the four major oil companies. Mobil, Shell, Agip and Total. These companies also re-export residuals and import refined product to meet shortage while the former company additionally transports crude oil from its source to the refinery. The shipping tarriff is 3 cents per liter for Assab-Massawa; 2 cents Assab-Dijibouti; 3 cents Aden-Assab; 3.5 cents; Aden-Massawa. Ethiopian Herald (March 27, 1981, p.3)

Prior to the Ethiopian revolution, Iran and Saudi Arabia were the two major suppliers of crude oil(See statistical abstracts). Since then, with political development in Ethiopia and the Middle East the source of supply has been hanging, and currently the Soviet Union is believed to be the main supplier.(Beijir, p.14)

26 It is important to note that there is a differential between large and small tankers which according to UN estimate could be as high as US$ 4-5 per barrel of crude oil. Ethiopias present port capacity for oil tankers is 350,000 metric tonnes and is among the least in Africa (OAU/ECA,P.73). Thus the benefit of investing in order to increase port handling facilities for large tankers could not be overemphasized.

27 The tariff of petrol tankers is 11 cents per litere for Assab-Addis Ababa and 2 cents for Massawa- Asmara. If entry is via other points it is 12.644 cents.(Ethiopian Herald,p.3)

28 OAU/ECA,PP.71-72

29 See appendix 3h

30 Bertlin and Partners, Ethiopian Ports Master Plan Study, Economic Studies.Vol.2, (August 1981) P.191.

31 Ibid,PP.192-193

32 World Bank, Energy in Developing countries, P.56.

33 A fifth case was at first attempted based on result obtained after fitting linear trend of CEC. Due to the weak relationship obtained (R^2=0.4) and the virtual similarity of the results (even if included) with one of the alternatives examined (case 1b) it was dropped.

34 These elasticities are results of different studies made for LDC's. Some writings indicate that energy demand in oil importing LDC's increaese 1.5-2.0 times the growth rate of the GDP. (Bertilin and Partners). The upper range pertaining to the relatively more industrialized or relying on energy intensive production structure etc. and the lower bound for predominantly agricultural and less developed of the group. A more recent estimate by The World Bank puts the corrresponding figure at 1.3 (Alan S.Manne, Energy, International Trade and Economic Growth, World Bank, August 1981,p.7).

Thus GDP elasticity of demand for CE 1.5 from the former (Considering the dominance of peasant agriculture and smallness of industrial base of the country) and 1.3 from the latter are taken for use in our scenario building.

[35] 2.5% is the estimated population growth rate-CSO.

[36] The 7.5% is the annual GDP growth rate targeted by CPSC for 10 years plan which covers the period from 1976 to 1985E.C. However since the CPSC's base year (1976) differs from ours (1973) we will use 4.7%(average actual growth rate for 1971,1973 E.C.) for the intermim period (Addis Zemen, Meazia 13,1974E.C.,0.5). The 5.3% GDP growth rate is one that is estimated by the World Bank for LDC's for oil importing LDC's (Alan S.Manne,P.6).

[37] $C_o = P_o(^{CEC}/_{CAP})$ where $^{CEC}/_{cap}$ equals to 30.68 Kgce and P_o is population equals to 31,596,200 both for 1973. See appendix 2b and 2e.

[38] Beijir,p.32

[39] See appendix 3i

[40] See appendix 3g

[41] The last two growth rates are implied in the projection made,-See Beijir,p.32

[42] The inclusion of dependent lagged variable Ft-1 in equations 3c and 3d requires making restrictive assumptions(before using it) since it could be coorelated with the disturbance term. Since the two equations were not employed for our projection we choose not to go to the details.

Two sets of figures (price) were at first attempted. Both were based on nominal price per barrel of Saudi Arabian light crude(at Ras Tanura). The first was adjusted for cummulative inflation rates by GDP deflator and the second by export unit price(from IFS); and both were adjusted for currency exchange rate variations. Though marginal the former showed a relatively better fit. For the data base, see appendix 2c.

[43] Three different prices(see following pages for the detail) were used for the projection. Due to the smallness of the price coefficient no significant difference was observed, leading to the use of only one price level.

44 To arrive at GNP/cap for 1980/81 ie 1973 E.C. we took GDP at current factor cost and converted it to US dollars. Accordingly GDP/cap of US$ 122.3 was obtained. The absence of any significant difference (in many cases less than 9 million) between GDP and GNP figures for Ethiopia (according to information from (CPSC) led us to use the available GDP figure,

45 In calculating the share of electricity and LF in total demand for CE 7% and 93% respectively was taken. Note also that 1MT of LF is equal to 1.47 mt e and 1000 KWH is equal to 0.123 mtce

46 Allane Manne, P.12.

47 This is computed by taking shipping tariff rate of 3 cents litre from Aden to Assab (Ethiopian Herald, p.3). To make the figures donsistent with the other variables, it is converted to constant 1964 EC prices by deflating it with the GDP deflator.

48 The foreign exchange requirement will be underestimated for two reasons. First, due to lack of disagregated cost data foreign exchange requirement for electricity production is not included. Secondly foreign exchange requirement of LF itself does not include those involved in refining and internal transport and distribution.

49 Operating expenditure of electricity (table below) is computed by deflating operating expenditure of EELPA(see table 4.1.0) and allowing it to grow at 2.4% ie average annual growth rate for 1963-73 E.C. Accordingly 9.04,10.17 and 11.46 cents/KWH at constant 1964 E.C prices is used for 1973, 1978 and 1983 respectivly.

Operating Expenditure in Birr 1964E.C(millions)

Cases	1973	1978	1983
	49.9	85.2	163.7
1a	49.9	80.8	145.0
	49.9	78.3	123.1
1b	49.9	63.5	80.9
2	45.1	80.5	145.0
	45.3	87.6	181.5
3a	45.3	82.6	142.0
	45.3	57.6	73.5
	45.3	95.2	262.1
3b	45.3	88.1	173.5
	73.2	86.5	151.7
4	73.2	83.7	127.9

50 Simon Kuznets, quoted by C.F.Roos,"Survey of Economic Forecasting Techniques," Econometrica Vol.23,1955,p.303.

Notes to Chapter 4

[1]OAU/ECA, p. 213.

[2]The opportunity cost is the real value of that form of energy used in its most desirable alternative be it in production or exchange. It is only when the product could not be traded or substituted for a traded good that we take the opportunity cost to be equal to its cost of production.

[3]World Bank, Energy in Developing Countries, p. 15.

[4]Substitution of one energy form for another though quite substantial ofter requires a change in technology employed or appliances used (for preductive and domestic uses respectively,) which in turn requires capital investments. In many cases the substitution will therefore boil down to be one between capital and energy.

[5]See appendix 6a for shadow price of fuel.

[6]Ethiopian Herald, March 27, 1981, p. 3.

[7]Ibid.

[8]Negarit Gazeta, Proclamation No. 221 of 1982.

[9]Diplomatic and other foreign residents are for instance also covered by the subsidy. Many LDC's have now come to realize the necessity of responding to International Price Change, and have started passing price increase immediately on to the consumer.

[10]This too, need to be supervised carefully, since differential prices usually leave room for corruption, and may not bring the intended benefit to the desired group or sector. Thus, while subsidy on products considered to be consumed by low income people may be justified on equity grounds, the possibility that such products could be diverted to other uses need also be considered along with the adminstrative and other costs of inspection it entails and the extent of its effectivness.

[11]According to the press release by the Minister of Trade, the governments policy seems to encourage the reverse. He said "prices on black and white naphta... have been minimally increased. ... (for) the oil used for lamps... not only has the government decided to decrease its price, but it also lifted taxes that used to be imposed on it." (Ethiopian Herald, p.3)

[12]Beijir, p. 42.

[13]R. Turvey and D. Anderson, Electricity Economics, A World Bank Research Publication (London: The Johns Hopkins University Press), 1977, pp. 6-7.

[14]See Appendix 3c

[15]Turvey and Anderson. p. 7. et passim. For a short summary of how the accounting cost is determined. See pp. 7-8.

[16]Ibid., pp. 8-10.

[17]Ibid., p. 203

[18]Ibid.

[19] Ibid., p. 13.

[20] Compared to the 1964 E.C. tariff rate, the existing tariff (revised in 1971 E.C.) partially corrects this problem. (See Table 4.2). Apparently declining block tariff rates make cost to the small consumer - largely low income people - of an extra Kwh more expensive than for large consumers.

[21] Turvey and Anderson, p. 205.

[22] Ibid.

[23] Unfortunately the diminishing reserve of Electricity supply (installed capacity) does not give much hope in this regard, at least until the projects underway, commence production.

[24] World Bank, Energy in the Developing Countries, p. 52.

[25] European Community - Africa-Caribean-Pacific; The Courier, No.51 (September-October 1978), p. 83.

[26] Development and Cooperation, No. 5 (October - November, 1981), p.9.

[27] Ibid., p. 10.

[28] In trying to see efficiency it is important to distinguish the various phases (steps) of energy process. First we have the transition from gross energy (step 1) to net energy (step 2) in which loss of energy (low efficiency) is observed. This covers the extraction, refining and transporting of fuels and the generation and transmission of electricity. The greatest loss of energy however, occurs as we move from step 2 i.e. from where it is ready for use to step 3 where the various forms of energy are utilized for different functions in production, transport and consumer activities. See Figure 4.1.

[29] The World Bank, Energy in Developing Countries, p. 56.

[30] IMF and the World Bank, Finance and Development, Vol. 16, No. 14 (December 1979), p. 18.

[31] The World Bank, Energy in Developing Countries, p. 57. For estimates of potential savings, see appendix 4d.

[32] Beijir, Appendix IV

[33] United Nations, Energy Development in Latin America (Geneva, 1957), p. 82.

[34] It is generally felt that the relative waste of energy (especially in the sphere of production) is to a greater extent characteristic of the degree of development obtained i.e. use of inefficient methods, machines, etc. That may be so. But nonetheless it would be wrong to say such waste is entirely unavoidable, nor could it be reason for inaction.

[35] Ministry of Industry, "On the substitution of electric for fuel wood and oil fried boilers", January, 1977, pp. 1-2. (unpublished), see also appendix 4e.

[36] Unfortunately according to some knowledgeable people, the agreement made is rather premature. They hold the view that if these industries

switch to electric boilers, EELPA will not be able to handle it with its present reserve.

There is one interesting point to note in this connection. In 1961 E.C. the Bahar Dar textile mills switched from electric fired to fuel fired boiler. According to EELPA's 1961 E.C. annual report "this alone accounted for a reduction of 13 million kwh in production" (p.16). If computed on the bases of relations on appendix 4e, the fuel cost in today's price would be well over 800,000 birr per year!

[37]The World Bank, Energy in Developing Countries, p. 55.

[38]Tesfaye Dama and Zelleke Tegenu, "Determination of Heating values of Domestic Fuels and Efficiencies of Local Appliances", A.A. University, Faculty of Technology, May 1980. (Mimeographed), see appendix 4f.

[39]Ibid.

[40]World Bank, Energy in Developing Countires, p. 53.

[41]Ministry of Mines, Energy and Water Resources, Ethiopian National Energy Committee and the Beijir Enstitute of the Royal Swedish Academy of Sciences, Stockholm, Workshop "Policy Issues in Ethiopian Energy Development," (Nazret : May 15-18, 1981), appendix 1-2, (unpublished).

[42]The World Bank, Energy in Developing Countries, p. 54.

[43]See appendix 4g.

[44]ECA, "Report of the Technical Panel of Experts on Geotermal Energy," (Addis Ababa, October 30, 1981), p. 3 (mimeographed).

[45]G.M.D'c Paoke and Getahun Demissie, "Geothermal Energy: An Inexhaustible Resource of Great Economic Importance for Ethiopia." SINET, An Ethiopian Journal of Science, Vol. 2, No. 2 (December, 1979), p. 106.

[46]ECA, October 30, 1981, p. 12

[47]Ibid., p. 13.

[48]Getahun Demissie, "Geothermal Exploration Drilling at Lake Langano," SINET Newsletter, Vol. 5, No. 1, (January, 1982), p. 1.

[49]ECA, October 30, 1981, p. 13.

[50]Ibid., p. 19

[51]See appendix 4h

[52]OAU/ECA, p. 86.

[53]ENEC, "A Preliminary Discussion Paper for Possible Ethiopia - Aid Donor Country Cooperation, (Addis Ababa: June 19, 1978), pp.3-4 (mimeographed).

[54]Ibid., p. 4.

[55]OAU/ECA, p. 144.

[56]The Courier, p. 72.

[57]ECA, December 1980, p. 2.

[58]ENEC, p. 21.

[59]See appendix 3b

[60]ENEC, p. 10.

[61]ECA, "New and Renewable Sources of Energy in Africa," (Addis Ababa: January 12-16, 1981), p.4.

[62]Ibid.

[63]World Bank, Energy in Developing Countries, p. 38.

[64]"Solar Energy: A Resource for Development in Africa," SINET Newsletter, Vol. 2, No. 10, (October 1979), p. 7.

[65]Another type of alcohol which can also be produced similarly, but not widely considered (owing to technological problems that it poses) is Methy/Alcohol - Methanol.

[66]World Bank, Alcohol Production from Biomass, in the Developing Countries, (Washington D.C.: September, 1980), p. 5.

[67]Ibid.

N.B. For detailed account of the processes, the technology employed and the economics of ethanol production, see pp. 5-13.

[68]Dimitri Th. Kourlourianos, "Feasibility Study on the Production of Ethanol from Molasses in Ethiopia Comments," Development Projects Study Agency, (Addis Ababa, December 29, 1980, p. 3. (mimeographed).

N.B. The assumption regarding Fincha Project is very critical in view of the very high capital cost of the project and the associated problem of financing.

[69]Ibid.

[70]Ibid., pp. 14-15

[71]"Brazillian Cars. Booze Guzzlers," The Economist, (December, 13, 1980), p. 60.

[72]Angela Melamade, "Comments on Production of Ethanol from Sugar Cane," SINET Newsletter, Vol. 3, No. 4 (April, 1980), p. 3.

[73]Ibid.

[74]"Diesel Engines Running on Vegetable Oils" SINET Newsletter, Vol.6, No. 2 (February, 1982), p. 8.

It is interesting to note that the faculity of Agriculture of Mio University in Japan has done similar experiment with Eucalyptus oil, which they mixed with 30% gasoline and used it as fuel in "running a car mounted with a 550 c.c. engine at a stable speed of 40 kilometers an hour and for operating engines of farm use." (SINET Newsletter, Nol. 3, No. 2, February 1980, p. 7.)

[75]Ibid.

[76]Elizabeth Cecelski et al, Household Energy and the Poor in the Third World: Resources For the Future, (Washington D.C.: February 1980), p. 36.

[77]Ibid.

[78]Believed to contain "about two-thirds as much heat as natural (oil field) gas" (The Courier, p. 75), where condditions are favourable, it looks quite promising in contributing to rural electrification scheme.

[79]Cecelski, p. 86.

[80]Ibid.

[81]Ibid.

N.B. These are fossil fuel savings, reduced labor force savings in fuel wood as well as grasses, straw and other crop residue can be used for animal fodder and bedding reduced fuel expenditure by individuals and communeless house hold labor for women, improved hygenic conditions for rural areas, mechanization of some processing tasks and local generation of electricity and less gap between the standard of living in cities and villages.

[82]Beijir, p. 23.

[83]David French, The Economics of Renewable Energy Systems for Developing Countries, (Washington D.C.: January, 1979), pp. 22-31.

[84]Even community based large scale plants generally considered to be economical has come under question based on such consideration as management cost which could be expensive, skilled technicians needed to run the system, costly distribution networks and special pumps required, etc. The dozens of tonnes of water required for the plant every day is also another limiting factor, especially where water is scarce or far. (See French, pp. 22-31.

[85]Comparison of energy balances between using organic waste directly for fuel in a fire and converting it to biogas shows that in the latter 26 percent of net energy could be delivered for end use while in the former the corresponding figure is only 10 percent. (Cecelski, p. 37).

[86]"Solar Energy: A Resource for Development in Africa", SINET Newsletter, Vol. 2, No. 10, p. 5.

[87]Ibid.

[88]OAU/ECA, p. 156.

[89]Beijir, p. 25.

[90]OAU/ECA, p. 162.

[91]UNESCO, "Solar Power for Sahel: A UNESCO Feasibility Study" Buletien of the Regional Office for Science and Technology for Africa, (Nairobi, Vol. XVI, No. 3 (July - September 1981), p. 8.

[92]ECA, January 12-16, 1981, p. 12.

[93]Ibid.

[94]ENEC, pp. 6-7.

Notes to Chapter 5

[1]Karl Marx, Capital, Vol. I, (Progress Publishers, Moscow, 1977), p. 703

[2]See appendix 5a

[3]Cecelski, p. 89.

[4]Keith B. Griffin and John L Enos, Planning Development, (London: Addison-Wesly Publishing Company, 1970), p. 45.

[5]Demmisu Gemeda, et al, "Science and Technology for Development," SINET Newsletter, Vol. 2, No. 8, (August, 1979), p. 3.

[6]Ibid.

[7]Charles Cooper, ed., Science, Technology and Development. (London: Frank Cass and Company Limited, 1973), p. 113.

[8]Ibid.

[9]Mekonnen Tesfahunegn and Tesfaye Taffesse, "Fuel Oil Prices, Transportation and Interaction: Spatial Relationships," Part I, Addis Ababa University, November, 1981, p. 3 (mimeographed). For illustration see appendix 5b.

[10]Science and Technology Commission, Draft discussion document on "Policy Issues in Ethiopian Energy Development", May 1981, p. 2.

[11]Ibid.

SOCIO ECONOMIC INDICATORS OF DEVELOPMENT FOR SELECTED COUNTRIES. Appendix 2a

Country	Income Per Capita 1978 U.S. Dollars 1	C.E.C. Per Capita Kgce 2	Steel Consumption per Capita 3	Contribution of Agriculture to G.N.P. % 4	Contribution of Industry to G.N.P. % 5	Population Per Hospital Bed 6	Population Per Physican 7	Birth rate (Crude) / per thousand 8	Death rate (Crude) per thousand 9	Life Expectancy 10	Daily Calorie per capita (as percentage of requirement) 11	Adult literacy Rate percentage 12
Ethiopia	120	20		54	13		76320	49	25	39	75	38*
Tanzania	230	65		51	13		15450	48	16	51	89	66
Kenya	330	139		41	19		11950	51	14	53	88	40
Egypt	463	463		29	30		1070	37	13	54	109	44
Zimbabwe	480	579		20	35		700	48	14	54	108	39
India	180	176		40	26		3620	35	14	51	91	36
Indonesia	360	278		31	33		14580	37	17	47	105	62
Thailand	490	327		27	27		8170	32	8	51	105	84
Jordan	1050	535		11	29		1940	46	13	56	82	70
Jamaica	1110	1823		9	39		3530	29	4	70	119	80
Mexico	1290	1384		11	37		1820	38	8	65	114	74
Argentina	1910	1873		13	45		530	21	8	71	125	94
Italy	3050	3230		7	42		490	13	9	73	136	98
Japan	7280	3825		5	40		850	15	6	76	126	99
U.S.A.	9590	11374		3	34		580	15	9	73	135	99

SOURCE: The World Bank, World Development Indicator August 1980.

DATA BASE FOR THE REGRESSION ANALYSIS - CEC AND ECONOMIC ACTIVITY Appendix 2b

Year E.C.	Gross Domestic Product per Capita, in Birr, constant 1953/54 price	Agricultural Portion of GDP/Cap	Industrial Portion of GDP/CAP	Transport Portion of GDP/CAP	Industrial (without small scale) Portion of GMP/Cap	Commercial Energy Consumption Per Capita KGCE	Liquid fuel Consumption Per Capita KGCE	One Year lagged Gross Domestic Investment per capita
	1	2	3	4	5	6	7	8
1958	130.70	75.45	18.52	05.76	13.59	17.86	16.15	17.48
1959	133.94	76.32	[illegible]	[illegible]	15.31	20.42	19.35	18.37
1960	136.25	75.53	19.95	06.11	15.07	21.31	20.14	20.61
1961	140.61	75.62	22.14	07.28	16.34	22.32	20.94	20.26
1962	142/83	75.83	22.61	08.08	15.42	24.10	22.81	18.85
1963	146.31	75.66	24.10	08.74	16.64	26.16	24.73	17.84
1964	149.65	75.74	[illegible]	[illegible]	17.18	27.22	25.76	18.06
1965	150.11	75.28	24.06	09.55	17.19	28.45	26.94	20.44
1966	149.73	73.31	23.95	09.60	16.73	27.88	26.58	18.47
1967	145.37	70.21	23.04	09.42	16.03	24.74	23.18	[illegible]
1968	143.86	70.40	21.07	09.52	14.21	22.53	21.00	16.57
1969	141.23	65.54	21.02	10.97	14.30	22.43	20.84	13.10
1970	136.71	67.12	19.08	09.10	13.44	23.49	21.88	12.81
1971	140.64	65.59	21.75	09.65	14.81	25.63	23.98	11.92
1972	144.57	66.90	23.38	10.07	16.85	27.01	25.40	13.85
1973	145.71	65.57	[illegible]	[illegible]	18.61	[illegible]	27.91	[illegible]

SOURCES: Compiled from data obtained from:- Data for No's 1,2,3,4,5,8, - up to 1967 CSO, Statistical Abstract
- 1967 - 1973 NBE Quarterly Bulletin
- 1973 is planned figure
Data for No's 6 and 7 - Petroleum Data from EPC
- Electricity Data from EELPA
- 1973 Electricity figure is estimate by CPSC - CPSC

DATA BASE FOR INTER-COUNTRY COMPARISON Appendix 2c

Country	GNP per Capita in $ U.S.			CEC per Capita in Kgce		
	1975	1977	1979	1975	1977	1979
Chad	[illegible]	130	110	33	23	24
Ethiopia	[illegible]	130	130	20	22	23
Mali	[illegible]	110	140	28	30	30
Burundi	[illegible]	130	140	12	17	17
Upper Volta	139	130	[illegible]	21	23	[illegible]
Malawi	136	[illegible]	200	56	51	70
Rwanda	98	[illegible]	200	17	18	30
Benin	133	200	250	57	55	68
Sierra Leone	[illegible]	190	250	103	103	89
Tanzania	178	190	[illegible]	68	65	53
Zaire	[illegible]	130	[illegible]	71	71	103
Niger	156	160	[illegible]	33	37	40
Central Africa Rep.	[illegible]	250	[illegible]	41	81	55
Madagascar	[illegible]	240	[illegible]	65	76	94
Mauritania	340	270	320	187	193	185
Togo	261	300	350	64	93	117
Sudan	[illegible]	290	370	162	165	141
Kenya	238	270	330	144	141	180
Ghana	584	380	400	157	167	265
Senegal	386	430	430	176	175	266
Angola	330	300	440	166	185	208
Zimbabwe	550	500	470	671	598	791
Liberia	452	420	500	400	402	448
Zambia	435	430	[illegible]	496	403	858
Congo	516	420	630	143	140	213
Nigeria	360	420	670	107	107	83
Ivory Coast	609	690	1040	370	356	234

SOURCE: The World Bank, World Development Report: 1977,1979,1981

DATA BASE FOR [illegible] ANALYSIS. Appendix 2e

Year	Value of Imports Mill birr	Value of Exports and Re-exports Mill birr	Visible balance of Trade	Value of crude Petroleum Import Mill birr	Energy Imports as a Percentage of Exports	Jimma Coffee [illegible] Price U.S.¢ lb.	Balance on Current Account	Overall Balance
	1	2	3	4	5	6	7	8
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		

SOURCE: 1,2,7,8, N.B.E. Quarterly Bulletin Vol. 6. No. 2, June 1980
4 - EPC
6 - Ministry of Tea and Coffee Development
* Preliminary

DATA BASE FOR THE ANALYSIS OF INFLATION RATE AND [illegible] PROJECTION Appendix 2f

	Implicit Price index 1964=100	Petroleum Whole Sale price index 1964=100	General Price index 1964=100	Value of Crude Oil import adjusted for [illegible] Mill. Birr	F.O.B. Price of Saudi crude deflated by GDP deflator 1964=100	F.O.B. Price of Sa'di crude deflated by unit value of exports 1964=100	Gross Domestic Product in Constant 1964 birr	Real Value of imports Constant 1964	Real value of exports Constant 1964	Mid Year Population in 000
Year E.C.	1	2	3	4	5	6	7	8	9	10
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1966	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	[illegible]

SOURCE: Compiled on the basis of data:
- 1,3,7,8,9,10 - from CSO, statistical Abstract
- 4,5,6, - From EPC
- Unit value of exports is from International Financial Statistics, 1980
- 2 NBE
* To convert to price in Kgce multiply by 210

Appendix 3c   ISTALLED GENERATING CAPACITY & PRODUCTION IS AND SCS 197[illegible]

	Hydro Production		Thermal Production		Total Production	
	Capacity KVA	Production KWH	Capacity KVA	Production KWH	Capacity KVA	Production KWH
Koka (Awash I)	54,000	[illegible]6,935,000	150	-	54,150	86,935,800
Awash II	[illegible],000	74,[illegible]4,500	125	-	40,125	74,384,500
Awash III	40,000	74,190,000	-	-	40,000	74,712,000
Fincha	105,000	184,190,000	350	-	105,350	184,190,000
Aba Samuel	8,200	8,064	-	-	-	-
Addis Ababa S.P.	-	-	[illegible]	-	6,250	-
Alem Maya + G[illegible]	-	-	[illegible]	191,740	[illegible],910	191,740
Dire Dawa	-	-	[illegible]	237,[illegible]	9,625	237,800
Total IS	247,2[illegible]	420,[illegible]	15,410	429,540	262,610	120,659,904
Adegrat	-	-	[illegible]	376,[illegible]	[illegible]	76,400
Agaro	-	-	712	1,393,[illegible]	71[illegible]	1,393,297
Arba Minch	-	-	[illegible]	1,[illegible]69,320	[illegible]	1,169,320
Asebe Teferi	-	-	673	[illegible]	673	723,464
Assab	-	-	[illegible]	53,[illegible]	3,875*	10,080,260*
Axum	-	-	[illegible]	862,[illegible]	679	862,654
Bale Goba	-	-	[illegible]	[illegible]	4[illegible]2	965,516
Batti	-	-	[illegible]	[illegible]	338	66,340
Bonga	-	-	[illegible]	102,0[illegible]	333	102,040
Buno Bedelle	-	-	[illegible]	[illegible]	273	123,246
Debre Marcos	230	[illegible]	[illegible]	1,[illegible]	1,[illegible]68	2,010,149
Debre Tabor	-	-	[illegible]	[illegible]	298	120,216
Dembi Dollo	230	[illegible]	[illegible]	[illegible]	418	654,844
Dessie	-	[illegible]	[illegible]	5,[illegible],234	2,9[illegible]	5,446,234
Dilla	-	[illegible]	[illegible]	1,[illegible]	901	1,704,990
Fitche	-	-	[illegible]	[illegible]	488	-
Gelemso	-	[illegible]	[illegible]	[illegible]	339	4,480
Ghembie	-	[illegible]	[illegible]	[illegible]	334	318,600
Ghion	[illegible]	[illegible]	[illegible]	610,[illegible]	560	1,045,110
Gondar	-	[illegible]	[illegible]	4,2[illegible]	1,613	4,276,000
Gore			80	67,865	80	67,363
Hagere Hiwot			[illegible]	187,266	865	1,875,266
Hosaena			[illegible]	20,500	408	20,500
Jijiga			[illegible]	[illegible]	658	895,030
Jimma	[illegible]	330,[illegible]	3,[illegible]	3,[illegible]	3,038	4,140,054
Kebre Dehar	-	[illegible]	[illegible]	[illegible]	274	469,600
Kombolcha	-	-	[illegible]	3,[illegible]	1,564	3,344,825
Metu	-	[illegible]	544	214,256	544	214,256
Mechele Boreng	-	-	526	[illegible]	526	790,458
Nekemte	-	-	1,1[illegible]	1,[illegible]	1,126	1,499,690
Shambu	-	[illegible]	[illegible]	107,075	278	107,075
Shashemenne	-	-	3,3[illegible]	6,719,420	3,355	6,719,420
Woldiya	-	[illegible]	[illegible]	[illegible]	33[illegible]	119,172
Wolayita Soddo	-	-	[illegible]	1,[illegible],440	1,[illegible]	1,880,440
Yirga Alem	-	-	[illegible]	2,[illegible]	1,125	2,007,568
Zewdai	-	-	[illegible]	807,346	375	807,346
Sub-Total SCS	965	[illegible]	[illegible]	[illegible]	36,9[illegible]*	59,583,00 *
Baher Dar	9.600	26,[illegible]	[illegible]	-	9.700	26,432,700
Total SCS	10,5[illegible]	[illegible]	33,[illegible]	47,1[illegible],865	45,669*	86,015,704*

* Assab includes 10,080, 260 KWH purchased from oil refinery and a guarantee supply of 2500 kVA

SOURCE: ECA Document ECA/NRD/EN3/30/2 December 1980, p. 1?-12

Appendix 4a

Developing Countries: Potential Savings in Commercial Energy Consumption, 1990
(million barrels a day of oil equivalent)

	Projected Consumption	Savings from				
		Pricing Policies[a]	Taxes and Regulations	Retro-fitting and technical Improvements	Interfuel substitution and scale Economies	Total Reduction
Electric Power[b]	6.5	0.1	(.) +	0.5	0.1	0.7
Agriculture	1.5	(.)	(.)	0.1	(.)	0.1
Households	[illegible]	0.3	0.1	0.1	(0.4)	0.9
Transport	7.5	0.1	0.1	0.6	(0.2	1.0
Industry	8.6	0.2	0.2	1.1	(0.3)	1.8
Other	0.5	0.1	[illegible]	(.	(.)	[illegible]
Total	30.6	0.[illegible]	[illegible]	2.[illegible]	[illegible]	[illegible]

(.) Less than .05 the unit shown

a Based on "High Case" projections of GNP [illegible] per year increase in oil prices as in World Development Report, 1980; a ratio of energy consumption to GNP growth of 1:1.2; and a price elasticity of energy consumption of -0.[illegible]

b [illegible] consumed in generation, station use [illegible] transmission and distribution

[illegible] Energy in Developing Countries, August, [illegible]

Appendix 3d **ELECTRIC POWER REQUIREMENT FOR NEW PUBLIC INDUSTRIAL PROJECTS**

PROJECT	Date of Completion (Eth.C)	Energy Requirement (MW.H)	Installed Power (KW)	Location
A. Projects Under Implementation				
1. Bahr Dar Oil Mills	1978	2590	360	Bahar Dar
2. Solvent Extraction of Oilcake	1976	1080	150	Nazareth
3. Maize Flour Mill	1974	2090	290	Debre Zeit
4. Metahara Sugar Factory	1974	1090	3060	Metahara
5. Harar Brewery	1976	1665	400	Harar
6. Dire Dawa Soft Drinks	1973	830	200	Dire Dawa
7. Rubber and Canvas Shoes (Expansion)	1974	0.14	380	A.A.
8. Maltery Plant	1976	1460	380	Assela
9. Adei Abe'a Cotton Factory	1974	6890	1770	A.A.
10. Kombolcha Textile Mills	1978	65220	9060	Kombolcha
11. Dire Dawa Textile Mills	1976	9825	1388	Dire Dawa
12. 4th Cement Plant	1977	42750	10080	Muger
13. Glass and Bottle Making Factory	1973	11880	1880	A.A.
14. Sickle Project	1975	270	80	A.A.
15. Paper Mill Expansion	1974	3720	500	Wonji
B. Projects for Which Finance is Being Solicited				
1. Kombolcha Oil Mills	1979	2590	360	Kombolcha
2. Finchaa Sugar Project	1978	N.A.	3040	Finchaa
3. Progress Cotton Mills	1976	3300	600	A.A.
4. Bahar Dar Textiles	1978	7740	1130	Bahar Dar
5. Bagasse Pulp and Paper Mill	1978/1977	58800	7120	Wonji
6. Paper Board Manufaturing	1977	N.A.	N.A.	"
7. Caustic Soda and Bone Meal	1977	38000	4070	Not Determined
8. Ethanol Plant	1976	580	N.A.	Wonji/Nazareth
9. 5th Cement Factory	1978	67500	16000	Dire Dawa
10. Brick Factory	1977	1430	2000	A.A.
11. Foundry and Spare Parts	1977	8100	5710	Not Determined
12. Tractor Assembly Plant	1977	25000	13000	" "
C. Projects Under Study				
1. Sorghum and Wheat Flour Mills	1976	2305	320	Dessie
2. Baker's Yeast	1977	4130	770	Wonji
3. Awassa Textiles	1981	74225	10310	Awassa
4. 4th Fibre Project	1977	N.A.	N.A.	Not Determined
5. Canvas Shoes	1976	2.8	1330	A.A.
6. Plastic Shoes	1980	0.70	250	A.A.
7. Leather Shoes	N.A.	N.A.	N.A.	Not Determined
8. Leather Goods and Garments	1977	0.45	240	Not Determined
9. Pencil, Manufacturing	1976	10	50	A.A.
10. Tyre Re-treading	N.A.	N.A.	N.A.	Not Determined
11. Used Motor Oil Re-cycling	1976	20	8	" "
12. Ceramic Factory	1978	N.A.	N.A.	" "
13. Radio Assembly Plant	1977	1470	800	" "
14. Improved Farm Implements	1978	N.A.	N.A.	" "
15. Truck Assembly Plant	1978	N.A.	N.A.	" "

SOURCE: Report to International Workshop on "Policy Issues In Ethiopia Energy Development" Nazareth, May 15 – 18 (unpublished)

Appendix 3b **FORECAST-POWER CONSUMPTION FOR THE NEXT 10 YEARS. MOST LIKELY GROWTH TREND**

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
GWH	460	520	570	620	810	920	970	1020	1070	1189	1321
MW	92	104	114	124	162	184	194	204	214	238	264

Source: CPSC

Appendix 3f **PERCENTAGE DISTRIBUTION OF TOTAL ELECTRICITY SALES IN 000'KWH**

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Industrial		55.3	60.0	59.0	56.0	57.0	56.0	56.0	54.0	55.0
Agriculture		–	–	0.15	0.24	0.24	0.17	0.20	0.24	0.22
Commercial		–	8.7	9.6	10.1	10.4	10.8	10.9	10.0	10.4
Domestic		36.7	22.3	20.4	21.1	21.2	21.2	22.4	23.2	23.3
Street Lighting		2.0	2.1	2.2	2.1	2.2	2.4	1.9	1.7	1.8
Staff		–	–	–	–	–	1.2	1.3	1.4	1.4
Special Rate		6.1	5.0	6.7	[illegible]	8.4	8.4	7.6	7.5	7.4
Total		[illegible]		100.0	[illegible]	[illegible]	100	100	98.0	99.5

N.B. 1. It does not include [illegible]

2. Original source in A.[illegible] but converted to G.C. by NBE

3. Staff includes [illegible] Stations

Compiled from NBE, Quarterly [illegible]

Appendix 3q

CONSUMPTION OF PETROLEUM PRODUCTS (METER CUBE)
(METER TONS)

	1966	1967	1968	1969	1970		1971		1972		1973		1974	
					ADDIS	ASMARA	ADDIS	ASMARA	ADDIS	ASMARA	ADDIS	ASMARA	ADDIS	ASMARA
Premium Gasoline	6760	9468	12214	15664	13355	5246	15103	5246	16057	5405	18283	5405	13990	3657
(0.739)	4995.64	6996.85	9026115	11575.70	9869	3877	11161	3877	11866	3994	15511	3994	10339	2703
Regular Gasoline	69949	73532	74080	75609	68999	10493	70748	11129	72497	10811	76312	11129	76630	10970
(0.730)	51062.77	53678.36	54078.4	55194.57	50369	7660	51646	8124	52923	7892	55708	8124	55940	8008
Kerosene	6059	5613	5784	6600	3816	2862	4134	3021	4611	3021	5247	3498	3021	2703
(0.780)	4726.02	4378.14	4511.52	5148.00	2976	2232	3225	2356	3597	2356	4093	2728	2356	2108
Diesel Oils	152617	159625	172091	178137	136567	63753	155963	62799	170431	65024	184421	71384	183468	63912
(0.832)	126977.34	132808.0	143179.71	148209.98	113624	53042	129761	52249	141799	54100	153438	59391	152645	53175
Fuel Oils	57679	68429	67441	75952	40700	49285	41972	51670	45946	56121	49444	49460	46900	60096
(0.926)	53410.75	63365.25	62450.37	70331.55	37688	45638	38866	47846	42546	51968	45785	55060	43429	55649
LPG	2554	2771	3100	3242	2444	1113	3021	1272	3180	1431	3657	1431	3657	1431
(0.656)	1675.42	1817.78	2033.6	2126.75	1381	629	1707	719	1797	809	2066	809	2066	809
Aviation fuels	50415	55935	55739	66495	41495	30048	46264	33228	52147	29094	57870	30048	52624	23212
(0.770)	38819.55	43069.95	42919.03	51201.15	31951	23137	35623	25586	40153	22402	44560	23137	40520	17873
Lubricants	6472	6545	6786	7762	4929	2544	5882	2703	6677	2226	6518	3021	7472	1908
(0.9)	5824.8	5890.5	6107.4	6985.8	4432	2290	5294	2433	6009	2003	5866	2719	6680	1717
Totals in MC (including flintoote waxes. etc.)					320989	167410	356919	172498	381403	174723	409702	186011	394916	169000
Country Total MC	304644	381918	397235	429461	488399		529417		556126		595713		563916	

N.B. - ASMARA CONSUMPTION IS FOR ERITREAS, NORTHERN TIGRAI AND BEGEMEDER AND SEMEIN PROVINCE

- ADDIS ABABA CONSUMPTION IS FOR THE REST OF THE COUNTRY

- ETCA BITUMEN CONSUMPTION NOT INCLUDED.

SOURCE: EPC

1975		1976		1977		1978		1979		1980		1981	
ADDIS	ASMARA	ADDIS	ASMARA	ADDIS	ASMARA	ADDIS	ASMARA	ADDIS	ASMARA	ADDIS	ASMARA	ADDIS	ASMARA
11288	1431	10371	1450	7449	1048	4428	11	991	35	1828	-	117	-
8342	1058	7639	347	5505	775	3272	8	732	26	1351	-	86	-
75358	7472	83795	5800	88121	5559	119183	4365	123823	10852	132239	12068	130,068	13,911
55011	5455	61170	1525	64328	4058	87003	3186	90391	7922	96534	8810	95,471	10,155
3498	2703	6087	4796	3880	6107	1961	839	1167	1290	633	1712	2,769	4,396
2728	2108	4748	1354	3026	4763	1529	654	910	1006	494	1355	2,160	3,429
174882	36725	191753	23158	202796	21517	241609	14032	267625	31059	291314	33917	294,892	27,728
145502	30555	159539	19268	168726	17902	201017	11674	222664	25841	242373	28219	245,350	23,070
46254	32592	52528	32513	49588	20152	50719	10681	57866	18731	61795	25108	62,442	41,722
42840	30180	48641	30107	45918	18661	46965	9890	53584	17345	57222	23250	57,821	38,635
4134	795	4606	257	5128	138	5850	93	6909	549	7075	344	7,660	305
2336	449	2602	145	2897	78	3305	52	3904	310	3997	184	4,328	172
53100	9539	54133	10535	57101	14086	86731	13900	71412	21147	56971	28534	49,759	27,256
40887	7345	41682	8110	43968	10846	66782	10703	54984	162283	43868	21971	38,314	20,987
5406	1113	7291	911	8187	898	9798	371	10756	626	11594	1007	11,171	728
4865	1002	6562	820	7368	808	8818	333	9680	563	10435	906	10,054	655
376792	92529	414784	80302	427272	69919	523112	44298	544740	84394	568529	102858	577,592	118,000
469321		495086		497191		567410		629134		671387			

Appendix 4e

ANNUAL SAVING FROM SUBSTITAUION OF ELECTRICITY FOR FUEL OIL

Name of Factory	A Fuel Consumption (tons)	B = A XP*[1] Annual Fuel Expense (Birr)	C Power Consumption (KWH)	D Tarriff ¢ /KWH	E = C x D Annual Power Bill Birr	F= B - E Annual Saving (Birr).
Akaki Textiles Factory	5,560	3589111.2	55600000	1.48	883,000	2706111.2
Dire Dawa Textiles Factory	6,350	4099074.9	63500,000	1.30	826,000	3273074.9
Ethiopian Pulp and Paper	4,500	2904856.2	45000000	1.39	626,000	2278856.2
United Oil Mills	4,500	2904856.2	45000000	2.20	990,000	1914856.2 *[2]
St. George Brewery	3,300	2130227.9	33000000	1.43	472,000	1658227.9
Addis Tyre	2,200	1420151.9	22000000	1.25	272,000	1148151.9
Ethio-Japanese Synthetic Texts	1,000	645523.6	10000000	1.38	275,000	370523.6
Rubber and Canvas shoe factory	1,000	645523.6	10000000	1.34	138,000	5007523.6
Addis Tannery	-	-	-	-	-	- *[2]
Akaki Oil Mill	1,000	645523.6	10000000	2.20	220,000	425523.6

Where i P is unit price of gas oil (0.54 cents/ liter.

*[1] Original price of gasoil used by the Ministry is replaced by the current price of gasoil and the relevant columns revised accordingly

*[2] Are not included in the table in conformity with the original table

Source: Ministry of Industry.

Appendix 4f

SUMMARY OF EFFICIENCY OF LOCAL APPLIANIES (percent)

Cooking Appliances	By Metal Stove (Charcoal) Closed lid	Openlid	By "Gulicha" (Eucalyptas Wood) Closed lid	Open lid
"Biret Dist"	30.3	27.6	15.0	14.6
Clay "Dirt"	25.6	26.5	9.4	10.2
Kettle	20.8	19.4	8.0	8.4
Jebenas	13.6	13.1	5.8	6.2

SOURCE: Addis Ababa University, Faculty of Technology . May 1980

Appendix 5a

Following are tabels that show the advantages of small scale industries in terms of increased output, employment, energy requirement, and increased number of industries that contribute to regional distribution.

TABLE (i) COMPARISON OF CAPITAL COST, FOREIGN EXCHANGE REQUIREMENT, EMPLOYMENT AND ENERGY BETWEEN [illegible] AND ALTERNATIVE TECHNOLOGY IN THE PRODUCTION OF 230,000 TONS OF NITROGEN PER YEAR

	Western	Alternative Technology
Number of Plants Capital Cost	1 U.S.$ 140 Million	26,150 (at 8.8 tons per plant U.S. $ 125 million (at 4,825 per plant)
Foreign Exchange Requirement	U.S. $70 million	Nil
Employment	1000	130,750 (at 5 per plant)
Energy	0.1 million MWH/Year	5.35 million MWH/Year generation

TABLE (ii) COMPARISON OF OUTPUT BETWEEN LARGE AND SMALL PLANTS HAVING THE SAME COST OF INVESTMENT

Type of Plant		Total Capital available for investment in mill. U.S.$	Cost of each plant million of U.S.$	No of units that can be set-up within the available capital	Total output per [illegible] in million U.S.$
Cement	large	35.00	35.00	1	[illegible]
	small	35.00	0.60	58	
Sugar	large	4.31	4.31	1	
	small	4.31	0.092	45	
Textile	large	6.15	6.15	1	[illegible]
	small	6.15	0.0205	300	0.0079

Source: STA[illegible] STAAK, Appropriate Technology for [illegible] The Case for Small-Scale Industries 1968 [illegible]

Appendix 4h

NEW AND RENEWABLE ENERGY TECHNOLOGIES AND APPLIANCES

Energy Sources	Liquid Transport Fuels	Centralized Electric Power	Decentralized Power	Heat
Solar		Thermal Electric photovoltaic solar pond	Thermal Electric photovoltaic	Solar passive solar pond Solar flat plate Evacuated tubed Solar Cookers Solar concentraters
Geothermal		Geothermal Electric	Geothermal small Power	Geothermal Direct heat
Wind		Wind Electric	Wind Electric Wind Shaft	
Hydro power		Hydro Power (including small hydro)	Mini hydro	
Biomass	Ethanol Methanos Vegetable Oils	Direct Combustion	1. Diesel with liquid biofuel 2. Diesel with Producer gas 3. Diesel with biogas 4. Direct combustion 5. Fuel cells based on liquid /gas fuel	1. Direct combution 2. Biogas 3. Producer gas
Fuel wood and charcoal		Direct combustion		Direct combustion of wood and charcoal
Peat	Methanol	Direct Combustion	1.Direct combustion 2.Gasification	Direct Combustion
Draught animals			Traction and shaft power	

SOURCE: Compiled from "Notes on the synthesis report", UN conference on New And Renewable sources of Energy, April 1981 p.4.

Bibliography

The Beijir Institute, Policy Issues in Ethiopian Energy Development, (Addis Ababa: May, 1981).

Cecelski, Elizabeth et al. Household Energy and the Poor in the Third World. Washington D.C.: Resources For the Future, February, 1980.

CSO. Statistical Abstract, Addis Ababa, Issues 1974, 1975, 1976, 1977, 1978.

Choe, B.J. Energy Consumption in Developing Countries, Washington D.C., World Bank, 1979.

Cooper, Charles, ed., Science, Technology and Development, London: Frank Cass and Company Limited, 1973.

Daniel, G.H. and A.G. Robinson, Planning of Investment in Fuel and Power in LDC's. Belgrade: World Power Conference, 1957.

Darmstadter J. et al. Energy in the World Economy, Washington D.C.: Resources For the Future, 1971.

Demmissu Gemeda, et al. "Science and Technology for Development," SINET News letter. Vol. 2, No. 8. August, 1979.

Development and Cooperation, No. 3. German Foundation for International Development, Bonn, 1981.

__________, No. 5, German Foundation for International Development, 1981.

"Diesel Engines Running on Vegetable Oils?" SINET Newsletter, Vol. 5, No. 2, February, 1982.

ECA, "New and Renewable Sources of Energy in Africa", Addis Ababa: January 12-16, 1981 (mimeographed).

__________, "Report of the Technical Panel of Experts on Geo-thermal Energy", Addis Ababa, October 30, 1981 (mimeographed).

__________, "Report of the Technical Panel of Experts on Hydro-Power", Addis Ababa, October 20-24, 1980, (mimeographed).

__________, "Study on Electrical Energy Development in Ethiopia", Addis Ababa, December, 1980.

The Economist, London, December 13, 1980.

__________, London, June, 1981.

__________, London, March 1982.

Ethiopian Electric and Power Authority, Annual Reports 1970, 1971, 1972, 1973, 1974, 1975, 1976, 1977.

The Ethiopian Herald, Addis Ababa: Berhanena Selam Printing Press, March 27, 1981.

Ethiopian National Energy Commission, "A Preliminary Discussion Paper for Possible Ethiopia-Aid Donor Country Cooperation", Addis Ababa: June 19, 1978 (mimeographed).

European Community-Africa-Caribean-Pacific, The Courier, No. 51, Brussels: Jean Durieux, September-October, 1978.

Eyasu Sirak, "Appropriate Technology for Africa: The Case of Small-Scale Industries", Addis Ababa, 1976 (mimeographed).

French, David. The Economics of Renewable Energy Systems for Developing Countries, Washington D.C.: January, 1979.

Getahun Demissie "Geothermal Exploration Drilling At Lake Langano", SINET Newsletter, Vol. 5, No. 1. (January, 1982).

Griffin, Keith B. and John L. Enos, Planning Development, London: Addiso-Wesly Publishing Company, 1970.

Hirshman, Alberto O. The Strategy of Economic Development. London: Yale University Press, 1958.

IMF and the World Bank, Finance and Development, Vol. 16, No. 14, (December, 1979).

__________, International Financial Statistics Yearbook, Washington D.C. 1981.

Kourlourianos, Dimitri Th. "Feasibility Study on the Production of Ethanol From Molasses in Ethiopia, Comments" Addis Ababa: Projects Development Agency, December 13, 1980 (mimeographed).

Kuznets, Simon, "Survey of Economic Forecasting Techniques", Econometrica, Vol. 23, 1955.

Lambertni, A. Energy and Petroleum in Non-OPEC Developing Countries 1974-1980, Washington D.C.: World Bank, 1976.

Leigh, John G. et al. Energy and Development A Preliminary Analysis for Less Developed Countries. Mclean, The Mitre Corporation, 1979.

Manne, Alan S. Energy, International Trade and Economic Growth. Washington D.C.: World Bank, August, 1981.

Marx, Karl. Capital vol. I Moscow: Progress Publishers, 1977.

Mekonnen Tesfahunegne and Tesfaye Taffesse, "Fuel Oil Prices, Transportation and Interaction: Spatial Relationship", Part I Addis Ababa University, Novemeber 1981. (Mimeographed)

Melamade, Angela, "Comments on Production of Ethanol from Sugar Cane", SINET Newsletter, vol. 3, No. 4, (April 1980)

Ministry of Industry, "On the substitution of Electric for fuel wood and fuel fired boilers" (in Amharic) January 1977, (Mimeographed)

National Bank of Ethiopia, Quarterly Bulletiens, Addis Ababa: Economic Research and Planning Division, Issues 1977, 1978, 1979, 1980 1981.

Negarit Gazeta. Addis Ababa, Berhanena Selam Printing Press, Procalamation No. 221, 1982.

OAU/ECA, Energy Resources in Africa, Addis Ababa: 24-28 March, 1980.

Paola, G.M. Di and Getahun Demissie, "Geothermal Energy: An Inexhaustible Resource of Great Economic Importance for Ethiopia," SINET - An Ethiopian Journal of Science, vol. 2, No. 2, December, 1979.

"Solar Energy: A Resource for Development in Africa" SINET Newsletter vol.2, No. 10, October 1979.

Tanzer Michael. The Energy Crises: World Struggle for Power and Wealth. New York: Monthly Review Press.

Tesfaye Dama and Zelleke Tegenu, "Determination of Heating Values of Domestic Fuels and Efficiencies of Local Appliances." Addis Ababa University, Faculty of Technology, May 1980. (Mimeographed)

Turvey, R. and D. Anderson, Electricity Economics: A World Bank, Research Publication. London: The John Hopkins University Press, 1977.

UN. "Energy Consumption in Latin America" Economic Bulletien for Latin America, Santiago. 1956.

______ "Energy in Latin America", Geneva: Department of Economic and Social Affairs, 1957.

______ "Energy in Latin America", Economic Bulletien for Latin America vol. XV, No. 2, May 1970.

World Bank, Energy in the Developing Countries, Washington D.C.: August 1980.

______ World Development Report. Washington D.C.: August 1979, August 1980.

DECLARATION

I, the undersigned, declare that this thesis is my work and that all sources of material used for the thesis have been duly acknowledged.

Name Ahmed Mohammed

Signature ______________

Place and date of submission

18 - 6 - 82