ENERGY AND ECONOMIC GROWTH IN ETHIOPIA

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1. ENERGY RESOURCES

A comprehensive presentation of Ethiopia's energy resource is available in CESEN studies [CESEN 1986]. The following brief portrayal of these resources is based on those studies.

1.1 Hydro-energy

The gross hydro-energy potential of the whole Ethiopian territory is in the order of 650 Twh/year which is estimated to be 8 per cent of Africa's potential. More than three-quarters of this potential is available from mountain reservoirs with flow regulation. About one-fifth of the hydro-energy is available as river plain flow. Between one-third and one-half of the total potential is due to the Blue Nile basin (280 Twh/year). The Blue Nile and the Omo basins taken together contribute close to 400 Twh/year to the gross potential. If exploited at 15 to 30 per cent of potential, the Blue Nile and the Omo basins could provide 70 to 120 Twh/year or about fifty times the present installed capacity in the hydro grid.

1.2 Geothermal

Practically all of the geothermal potential in Ethiopia is contained in the Rift Valley extending along the thin (60 km wide) main Ethiopian rift. Based on the geotectonic environment, the nature and extent of the hydrothermal manifestations, the chemical composition of the fluids and geothermometric calculations, etc., available resources suitable for power production have been estimated at about 700 MW.

1.3 Natural Gas

Significant natural gas resources have been discovered in the Ogaden region of eastern Ethiopia to the extent of at least 30 to 60 billion m^3, giving rise to considerable expectations of oil and gas potential, thereby spurring exploration activity in the area. For the country as a whole, however, the available information is insufficient to make even rough guesses of oil and gas resources and reserves. The level of exploration activities has been very low compared to other areas of the world with similar prospective potential as indicated by geological evidence.

1.4 Coal

Coal resources appear to be quite widespread in Ethiopia, with occurrences in at least one-half of the country's administrative regions. With the possible exception of a recent discovery at Dilbi in the south-west, the hitherto known deposits are of lignite category with relatively low heating value, often as low as 1,000 to 2,000 Kcal/kg. Other basic problems with currently known Ethiopian coal resources are the high ash content and occasionally high sulphur content. Moreover, the deposits exist in small patches.

1.5 Biomass

Wood biomass resources in Ethiopia amount to about 13.8 million Tcals in terms of standing stock and 930 thousand Tcals in terms of annual yield. The figure for the annual consumption is several times lower. Three regions, Kefa, Illubabor, and Bale, occupying less than one-fifth of the land area, account for over half of the wood biomass resources. Almost three-quarters of the total resource base is contained on one-third of the land surface. Nine regions, with about two-thirds of the land area, contribute a little over one quarter of the total wood biomass resource.

A major feature of the fuel-wood problem is the strong mismatch between the location of forest resources and the concentration of the population, largely occupying currently deforested land or areas which are being rapidly deforested. Thus, most of the exploitable resource, located in areas with relatively low population density, remains unutilized or is lost in the life cycle process, while over vast expanses of the country, excessive exploitation by the bulk of Ethiopia's population is leading to critical levels of deforestation.

1.6 Other Resources

1.6.1 Solar

The yearly average daily radiation reaching the ground is 5.20 kwh/m^2. Throughout Ethiopia, the annual distribution of mean global daily radiation is quite narrow, allowing the most efficient use of solar systems. The total primary solar radiation reaching the ground may be estimated at about 1,953 million Tcals/year.

1.6.2 Wind

The total wind resource may be estimated at 4.8 million Tcals/yr. Only a small part of this potential may be considered exploitable, however. Environmental constraints such as the disruption of land systems in the case of heavy concentration of wind machines limit the exploitable potential to around 240 Tcals/year or about 192 Mcals/km^2/year over broad areas of land.

2. ENERGY SUPPLY

2.1 Overall Energy Supply by User Category

Table 1 shows the Ethiopian energy supply/demand pattern for 1984. It makes a strong assumption that the consumed energy is what has been supplied. The household sector is by far the largest consumer of all forms of energy, and fuel- wood takes the dominant role. Ethiopia's per capita electricity consumption of about 25 kwh/year is among the lowest in the world. Likewise, petroleum per capita consumption is 3.4 per cent of the world average. It could be inferred from the table that energy in Ethiopia is mainly used for subsistence and not for development.

Table 1: The Ethioplan Energy Consumption in 1984
(in Tcal)

Consumer category	Fuel-wood	Dung	Crop residues	Bagasse	Char-coal	Electri-city	Oil prod.	Total	% of total
Agriculture	-	-	-	-	-	1.85	275	276.85	0.2
Industry	6,320	449	441	72.5	34.5	314	930	8,531	6.8
Transport	-	-	-	-	-	-	4,032	4,032	3.2
Pub. & commercial	-	-	-	-	-	120	21	141	0.1
Households	91,172	10,521	9,357	-	1,403	177	314	112,944	89.4
Other	-	-	-	-	-	15.9	351	366.9	0.3
Total	97,492	10,970	9,768	72.5	1,437.5	628.7	5923	126,629 1.7	100
% of total	77.2	8.7	7.7		1.2	0.5	4.7	100	

2.2 Electricity Supply System

The authority for power generation, distribution and billing in Ethiopia is bestowed on the Ethiopian Electric Light and Power Authority (EELPA), a parastatal established in 1956 under the Ministry of Mines and Energy.

Most of the electric power is supplied from the inter-connected system (ICS). This system is fed predominantly by five major hydroelectric plants of the country: Koka, Awash II, Awash III, Finchaa and Melka Wakana. The ICS accounts for over 90 per cent of the total public generating capacity, the remaining 10 per cent being made up of several small isolated, or self-contained, systems (SCS) numbering about 200. In addition to these, there are about 100 small private or cooperative producers and distributors who operate in isolated areas.

With a total of 368 MW of installed capacity, the EELPA ICS is the largest of Ethiopia's electric systems. This system currently reaches out from central Shewa in four major directions: to Harrar and Jijiga in the east, Arba Minch in the south, Bahar Dar and Gondar in the north-west, Dessie in the north-east and Bedelle in the west. This and the other available systems provide access to electricity to only about 10 per cent of the population.

2.3 Petroleum Supply System

The bulk of Ethiopia's oil supply is imported by the Ethiopian Petroleum Corporation (EPC), which also owned and operated the country's only refinery at Assab prior to June 1991. Transport to the inland demand centers is handled largely by the National Transport Corporation and by private truckers. Distribution and marketing of petroleum products are performed by four oil companies: Agip, Total, Mobil and Shell, which run depots, tank trucks and filling stations throughout the country. They also import refined petroleum products.

2.4 Biomass-based Energy Supply Scene

An important feature of the traditional fuel supply system related to the predominantly rural character of Ethiopia's population is the relatively small role played by commercialization in the overall supply. Direct collection by consumers met almost 90 per cent of the total consumption of biomass based fuels. In particular, commercialization is almost absent in rural settlements but becomes increasingly important for most fuels with greater urbanization.

To rationalize the supply and consumption of traditional fuels, the government extended its responsibilities in fuel-wood and charcoal trade in many parts of the country. Responsibility for the production, processing and marketing of fuel-wood and charcoal resides in the Wood and Charcoal Production, Processing and Marketing Enterprise (WCPPME) under the Ministry of Agriculture.

WCPPME has currently succeeded in capturing only a very small part of the total fuel-wood trade from private producers. Its operations are, infact, largely concentrated in Addis Ababa and surrounding towns. Only some 3 per cent of the urban fuel-wood and charcoal supply is currently met by WCPPME.

2.5 Alternative Energy Supply Initiatives

A few biogas pilot and demonstration plants have been set up with the support of governmental and non-government organizations. The total number of biogas plants in the entire country was 75 in 1985. The output capacity of the individual digestors in operation ranges from 2 m^3 to 12 m^3 per day. The makes are mostly of Indian metal dome types, and the users are, in most cases, private homes.

The conversion of agricultural residues into briquette fuels has not started to date. Preparations are underway to produce agri-residue briquettes from cotton stalks, wheat stalks and coffee husks. Up to 25,000 tons of such briquettes are to be produced per year for household and industrial uses. Based on the viability of this scheme, larger-scale production will be planned to make a fuller use of agri-residues in state farms and processing plants.

On the other hand, effort is being exerted to disseminate improved charcoal kilns to save energy normally wasted in wood to charcoal conversion.

Various models of improved stoves have also been studied, and demonstration and dissemination attempts have been made in the past few years. The fuel-wood-burning varieties of these stoves have cooking efficiencies of 25 to 30 per cent, which is more than double the figures cited for the traditional stoves. An improved charcoal stove variety *(Laketch)* is 25 per cent more fuel-efficient than the traditional counterpart. Attempts at commercializing this stove have proved successful.

3. ENERGY DEMAND TRENDS

Table 2 presents the energy demand situation in Ethiopia. It does not, however, tell the whole story about energy demand trends in the country but is a succinct representation providing a clue for further investigation.

With biomass fuels, the problem is one of heavy dependence on standing stocks of wood, deforestation, scarcity and price rises of fuel-wood, shift to modern energy forms or resort to agri-residue dung. The trend will continue with growth in demand generated mainly through increases in population.

With respect to petroleum, the unhealthy trend is notable from Table 2, which indicates a huge demand growth of about 23 per cent per year for the household sector. But, as far as electricity is concerned, there appear to be a healthy demand trend in the form of proportionately rising industrial demand.

4. OPPORTUNITIES IN THE ENERGY SECTOR AND IMPLICATIONS FOR KEY SECTORS

The energy sector in Ethiopia can indeed be looked upon as an asset rather than a liability to development. Several sectors can take advantage of the energy resources and, in fact, hinge their development on the availability of a wide range of energy forms to meet their needs at low costs. There are constraints in the development of the energy resources, but these constraints are expected to diminish with growth in the other sectors. Economic growth in the other sectors will generate increased demand for energy. The increased energy demand will mean economies of scale for energy projects and the resulting increases in energy sales will mean greater capability for investment in the energy sector.

A full discussion of the opportunities and constraints in the energy scene and its implications for key sectors will be beyond the scope of this paper. Only a sketch will be given hereunder.

Table 2: Final Consumption of Energy by Fuel Type and Sector, 1986-1990
(in 10 joules)

Fuel type & sector	1896	1987	1988	1989	1900	Average growth of cons'n.	%tage change of cons'n.
Biomass fuels	526,081.50	539,954.46	554,491.08	568,828.62	584,880.76	2.5	100
Household	490,277.34	502,958.93	516,419.22	529,499.08	544,317.36	2.5	93.1
Industry	18,416.06	19,015.60	19,533.45	20,214.53	20,854.00	3.0	3.5
Services & other	17,438.10	17,979.93	18,538.40	19,115.01	19,709.40	3.0	3.4
Petroleum products	29,977.32	31,266.76	33,488.82	35,012.54	33,494.14	4.0	100
Household	1,708.32	2,238.28	2,653.24	3,444.50	3,572.46	23.5	8.3
Agriculture	1,060.04	1,272.39	1,368.90	1,366.57	1,288.44	8.5	3.9
Transport	16,511.44	16,695.04	17,593.95	17,889.53	16,792.50	1.5	52.4
Industry	5,693.81	6,439.56	6,470.16	6,916.22	6,354.59	5.5	19.5
Service & other	5,000.72	4,621.49	5,382.57	5,395.62	5,495.16	2.0	15.9
Electricity	30,077.36	3,333.23	3,499.64	3,663.74	3,701.93	6.0	100
Household	921.60	880.21	937.66	1,061.96	1,160.03	3.5	28.7
Industry	1,798.26	1,968.15	2,048.69	2,040.43	2,003.00	4.5	57.1
Services & other	357.50	484.87	513.29	561.35	538.90	16	14.2
Total	55,136.19	574,554.44	591,479.54	607,504.90	622,076.85	3	

Source: Ethiopian Energy Authority.

4.1 Agriculture

Hydro- or geothermal based electricity can enhance the development of large irrigated farms (cotton, sugar-cane, fruit farms) and associated agro-industrial processing plants (ginnery, sugar mills and fruit canning), provided other inputs and means of production are available. The obvious benefits of such schemes are foreign exchange savings (through import substitution or export promotion) and employment generation. Amibara, Wonji and Nura Era farms in the Awash Valley are examples of such schemes.

Natural gas powered tractors, harvesters, etc. (if developed) can ease the problems of meeting the demand for imported petroleum fuels and/or manual labor, especially in hostile environments where human labor is hard to come by. It is inspiring to note that natural gas vehicles are being developed in a number of countries including Italy, Canada, USA, USSR, Indonesia and Pakistan [Mengistu 1991].

Photovoltaic (PV) electricity may prove a cheaper alternative as an energy source for small irrigation farms, if the cost per peak watt for PV modules continues to drop as at did in the past (between 1975 and 1985, the unit cost dropped by about ten-fold). Research into better techniques of crystal growth and large-scale production is expected to bring down the unit cost to below US$1 per peak watt.

There are areas where the agricultural sector can actually help develop the energy sector: sugar-cane plantations for the production of ethanol (a proven gasoline extender at a 20 per cent blend) can make an economic sense if petroleum prices rise perceptively.

Afforestation/reforestation/periurban fuel-wood plantation can help meet household energy needs which are being exacerbated by population growth and urbanization [Mengistu 1989].

4.2 Industry

Industry can also benefit as a consumer sector from the availability of a wide variety of energy resources as well as benefiting the energy sector itself by being an energy producer and saver.

The availability of hydroelectricity, geothermal energy and coal can be a decisive factor in the economic viability of the following energy intensive industries and industries that contribute to value added in the agricultural and mining sector outputs: mining (e.g., gold); ore processing/ refining; metallurgical industries; chemical industries; building materials industries; production of utensils and implements; manufacture of energy appliances and equipments; textile mills; food-processing industries; breweries; and wood-based industries.

Typically, hydroelectricity would provide the motive power and control energy, with geothermal and coal supplying process heat. However, electricity is versatile and can cover all the energy needs of a plant. A hypothetical steel plant with an output capacity of 100,000 tons/year (adequate to cover the construction steel needs of Ethiopia) would require an estimated 600 million kwh of electricity per year for ore smelting, refining and steel production processes. The production cost of hydroelectricity of that magnitude would run up to Birr 60 million. If produced from thermal sources (especially oil), however, the same amount of electricity would cost at least about three times as much (i.e., Birr 180 million per year). The savings by the hydroelectricity alternative are colossal.

There would be backward (e.g., inputs from the mining sector) and forward (e.g., transportation and marketing of products) linkages to industry. These conditions should, however, be regarded as opportunities (for investment and employment) rather than constraints against exploiting the energy resources of Ethiopia. One need only look at the multiplicity of benefits that would accrue to the Ethiopian economy if a serious effort were made at establishing an export-oriented wood-based industry. Yet the realities are that we have fallen short of meeting our fuel-wood needs.

It goes without saying that the availability of hydroelectricity would enhance the development of small-scale industries, given the right investment climate and other inputs.

Conversely,the following areas of activity illustrate the potentials of the industrial sector as an energy producer and saver:

- Ethanol production from molasses in existing sugar factories;
- Efficiency improvement in industrial energy consumption (housekeeping, retrofitting of old equipment, insulation of pipes, installation of power factor improvement equipment, recycling of waste heat [ENEC 1990];
- Solar energy substitution for hot water production or pre-steam raising; and
- In the long-run, switching to processes and products with high value added per unit of energy consumed.

4.3 Transport

Electric trains can be a superior alternative to other modes of transport in cases where passenger/freight transport demand level is sufficiently high and electricity supply is not a constraint.

Though trolley buses do not appear to be a viable alternative to urban bus transport until such a time when gasoil prices rise significantly [Mengistu 1991], there is a strong case for light rail transit, as pointed out in a CESEN study: "passenger loads are expected to attain levels in excess of 10,000 pass./hour on a large number of lines in Addis Ababa over the coming two decades, and the question of the convenience of installing rail systems to cope with urban traffic requirements is, therefore, not as remote a problem as many seem to think" [CESEN 1985].

There are, in fact, numerous types of electric traction systems offering optimum service at given passenger load levels in an urban context. The basic requirement is electrical energy, and in this, Ethiopia can have a comparative advantage.

There are competing and potentially attractive end uses and technologies for the use of natural gas (supplementary fuel in dual-fuelled engines, sole energy source in dedicated natural gas vehicles, condensate fuel source, conversion to liquid fuels) in Ethiopia. Condensate fuel (gasoline and gasoil) extraction appears to be a good starting point in practice, though the amount of gasoline and gasoil so obtained may initially cover a small percentage (about 5 per cent) of the national demand for these fuels.

Likewise, the transport sector can benefit from ethanol production. In this, Ethiopia has the potential to follow the trail of Zimbabwe, Kenya and even Brazil.

The transport sector in Ethiopia accounts for about 70 per cent of petroleum consumption. Petroleum imports consumed about 30 to 50 per cent of the foreign exchange earnings of the country in the 1980s. Given the increasing role of the modern transport sub-sector and escalations in oil prices, a more efficient use of petroleum in the transport sector can have positive implications on the economy as a whole. Such efficiency improvements can take the form of better maintenance and upkeep of vehicles to keep down the fuel consumption of vehicles, fleet operations management to coordinate trips, optimized the use of haulage capacities and fuel consumption monitoring, modal shift to mass transport systems such as buses in cities, etc. An analysis of the implications of a set of petroleum demand management policy measures indicated the possibility of a 9.7 per cent saving on our present consumption of gasoline and gasoil [Mengistu 1990].

4.4 Trade

Energy (in the form of oil, natural gas, coal, electricity and uranium) is traded internationally, involving huge transfers of money. Presently, Ethiopia's international energy trade is only in the realm of oil imports. However, the possibility of exporting secondary (surplus) hydro-energy to some neighboring states (Sudan and Djibouti, in particular) has been studied at length and the indications are that, under certain conditions, both Ethiopia and the importing states would benefit from the implementation of such a scheme.

Likewise, the export of natural gas to the Far East may not be a remote possibility and should, in fact, be given some thought.

An indirect, but extremely important, role of energy in trade is encountered in the context of transport energy. The viability of export of bulky commodities (e.g., mineral products such as marble, granite and soda ash; agricultural products of all types; energy carriers such as coal) can be markedly affected by transport costs which, in turn, are dependent on transport energy costs. One can cite the case of soda ash, marble and granite export costs (about Birr 5,000 per truck-load) and road transport costs (two way) of about Birr 2,000 for an average distance of 1,000 km from production site to seaport of exit. Rail transport would reduce the cost to about one-third of this. A well-developed transport infrastructure utilizing low-cost, preferably indigenous, energy would provide a competitive edge, especially for a country like Ethiopia whose exports are categorically raw/semi-processed bulky materials. Ethiopia should recognize its comparative advantage in energy resource endowment and develop these resources to the goal of assisting the export trade.

Internal trade of agricultural products, industrial raw materials and even energy carriers (e.g., charcoal) can also be facilitated through the development of an efficient and low-cost transport system. This would contribute immensely to the smooth functioning of the macroeconomy.

4.5 Households and Communities

Households and communities can benefit from the as-yet-not-too-scarce biomass-based energy for their cooking and lighting needs. Urhan households in particular can benefit from hydroelectricity at present and possibly from natural gas extracts in the future.

Photovoltaic technology may revolutionize life styles of rural households and communities. At the expected low prices, the electrical energy from PV sets may be used for lighting, TV , radio, clinics, hospitals, mills and water lifting.

Conversely, rural households and communities can help the energy sector by undertaking fuel-wood plantations. Households can also contrihute immensely to the sustainability of household energy supply and upkeep of the environment by using more efficient cooking stoves.

5. ENERGY POLICY

An energy policy is being drafted for Ethiopia by the Ethiopian Energy Authority (EEA). The policy draft will treat such issues as:

- energy supply and consumption;
- energy production costs and pricing;
- institutional setup of the energy sector;
- environmental implications of energy production and consumption patterns;
- energy self-reliance, import substitution and export promotion; and
- past policy problems in the sector.

The policy paper is expected to indicate outstanding problems in the sector, better ways and means of energy production, supply and consumption.

In the final analysis, the worth of the recommended policy would lie in its:

- practicality and implementability;
- guarantee for long-term sustainability of supply of the energy forms under the terms of the policy;

- effectiveness in the move towards an increased utilization of indigenous resources;
- stimulation of production and trade;
- effectiveness in substituting the various energy forms for human labour and using them for the improvement of the quality of life; and
- overall contribution for the smooth running of the macroeconomy.

So perceived, it is quite likely that the energy policy will place a strong emphasis on the development of hydroelectricity, biomass energy, oil and natural gas, and solar energy in Ethiopia. Controversial issues would naturally be encountered in the details of the policy -- i.e., regarding as to how, when, at what pace, etc., these resources should be developed.

6. CONCLUSION

The energy sector can contribute significantly to economic growth in Ethiopia. Indigenous energy, and in particular hydroelectricity, can enhance export-oriented agricultural production, agro-industrial processing, mineral production and industrial value added in several fields. Hydroelectricity also offers the opportunity for a more efficient and cost-effective transportation in urban centers and high density traffic corridors. Efficient and cost-effective transportation, in turn, can promote export trade as well as contributing to the smooth functioning of the macroeconomy.

The conclusions we draw from the present discussion should not be stretched beyond their rational limits. Although energy is an essential input for development, it can, in no way, be a substitute for other factors of development. It was not because we didn't appreciate the importance of our energy resources that development has been elusive to Ethiopia. It was rather because other macro-level factors like the political framework, economic policy, foreign relations, sense of nationhood, natural calamities, cultural creeds, technological backwardness, etc., did not provide an adequately favorable climate for development to take root. For the present, we can only conclude that, given the right environment, the energy sector can make a positive contribution to development in Ethiopia.

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Annex 1

a) Some Energy Units and Conversion Factors

1	Joule	=	0.238 cals
1	BTU	=	1055 joules
1	KWH	=	3.4×10^{3} BTU
1	Toe	=	12,000 kwh
1	Tcal	=	98 Toe
1	TWH	=	10^{9} kwh

b) Energy Contents (Average) of Some Fuels

Fuelwood (s.G = 0.6 dry)	=	3,500 kcal/kg
Charcoal	=	6,900 kcal/kg
Agriresidue	=	3,700 kcal/kg
Dung (dry)	=	3,300 kcal/kg
Kerosine	=	10,300 kcal/kg
LPG	=	10,800 kcal/kg