VISION 2020 ETHIOPIA: ENERGY AND DEVELOPMENT IN ETHIOPIA

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I INTRODUCTION

Before going into the main issues constituting the subject matter of this paper, I believe it would help to create a common understanding of the topic if I start by explaining what energy is and the related concepts or terms. Accordingly, I have provided at least a working definition of some of these concepts.

The etymology of the word 'energy' is traceable to the Greek *ergon* (meaning 'work') and the Latin *energia* [1], [2]. Currently, the term has also been adopted by Amharic. In short, 'energy' can be defined as the capacity to do work. It has many forms. Energy associated with motion is known as kinetic energy, and energy due to position or chemical composition is called potential energy. For example, while wind and running water have kinetic energy, water in a dam and fuel have potential energy.

Energy could be generated from various resources. Fuel wood, coal, oil, water and uranium (radioactive atoms) constitute the major sources of energy. Sources are commonly used with the term energy to indicate the source of energy. For instance, when we speak of wood energy, we are pointing to the energy generated from wood. Similarly, therefore, we speak of coal energy, atomic energy, water- or hydro-energy, based on the sources. Moreover, energy could be categorized as renewable and non-renewable, depending on the nature of the sources. Renewable energy is the energy derived from renewable sources. Wood, the sun, water, air, geothermal (underground heat/steam), and sea wave constitute renewable energy sources, while such sources as coal, oil and natural gas constitute non-renewable energy sources.

Scientifically speaking or in accordance with the laws of nature, energy can neither be created nor destroyed; it can only be transformed from one form into another. For instance, the potential energy of water can be transformed into electrical energy. This is what provides us with the electricity that we consume in our urban centers. Similarly, fuel energy is first transformed into thermal (heat) energy, then into mechanical energy and, finally, into electricity, thereby serving many purposes.

So far, it is attempted to explain the concepts related to energy from the perspective of its different uses in our day-to-day activities. Seen broadly, however, energy is the fundamental source of life. The cells of each and every living thing (be it plant or animal) need food to stay alive. And food is mainly used to generate the energy required for the sustenance of this life. It follows, then, that life and energy are inseparably linked.

Looking back at our everyday activities pointed out earlier, we find that energy is essential for many of our needs. Energy is necessary for cooking our food and providing light and heat at our homes; for commuting to our work or traveling to distant places; and for the equipment, services, and inputs that we use directly or indirectly at our offices or when we are out on fieldwork. To mention but few examples, we need fuel for surface (road or rail), air or sea transport. The machinery and

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equipment used for the agriculture and construction are driven by fuel or electricity. On this score, it may be argued that a backward agriculture such as ours is not a direct beneficiary of modern energy. This is true. However, it has to be noted that a backward agriculture also uses human and animal labor, and thus, it requires energy. On the other hand, our agriculture has gradually become the user of chemical fertilizers. Because fertilizers are produced in factories that consume enormous amount of energy, our agricultural production consumes, however indirectly, a lot of energy. Fertilizers themselves are considered as one form of energy input.

It goes without saying that the industrial sector is a major consumer of energy. The various production and auxiliary machines in industry cannot function without energy supply, be it as fuel or other forms of energy. Moreover, steel and cement, which are essential construction materials required for development activities, are manufactured in factories that consume enormous amount of energy. Whoever has watched the fleet of fuel tankers shuttling along the road to the cement factory at Mugher can easily recognize this fact.

The various equipment and apparatus (radio, television, computer, telephone, etc.) used by our modern information and communication technology cannot function without energy. It is also possible to cite other examples from the service industry (hotels, shopping centers, shops, etc.). However, the examples cited above are sufficient to demonstrate the all-embracing application of energy and its importance in all economic and social sectors.

II. THE LINK BETWEEN ENERGY AND DEVELOPMENT

There is a strong link between energy and development. Those countries with high consumption of energy are all highly developed. The reason, as has already been pointed out, is that all economic and social development undertakings need and use energy. Figures 1 and 2 below illustrate this with concrete data.

As demonstrated in Figure 1, the 1999 energy consumption of the developed countries such as Canada, the United States of America, Japan and the whole of Western Europe was the highest in the world (53%) compared to their share of the world's population (15%). On the other hand, while the population share of the less developed African and Asian countries (including Australia and Oceania) is two-thirds (67%) of that of the whole world, their energy consumption is less than a quarter (23%).

Figure 2 shows the 1999 annual per capita GDP and per capita energy consumption of 108 countries. As the chart indicates, although for some specific reasons some countries (e.g. the countries of Eastern Europe - relatively high energy consumers, and countries of South America – relatively low energy consumers) deviate from what may be considered the norm, when generally considered, those countries with low annual per capita income also have low annual per capita energy consumption, while those with high annual per capita income have a corresponding high annual per capita energy consumption. Accordingly, one can estimate the annual per capita energy consumption of a country if the annual per capita income of the country is known. As one could understand from these graphical and statistical data, there is a strong correlation between economic growth and energy consumption.

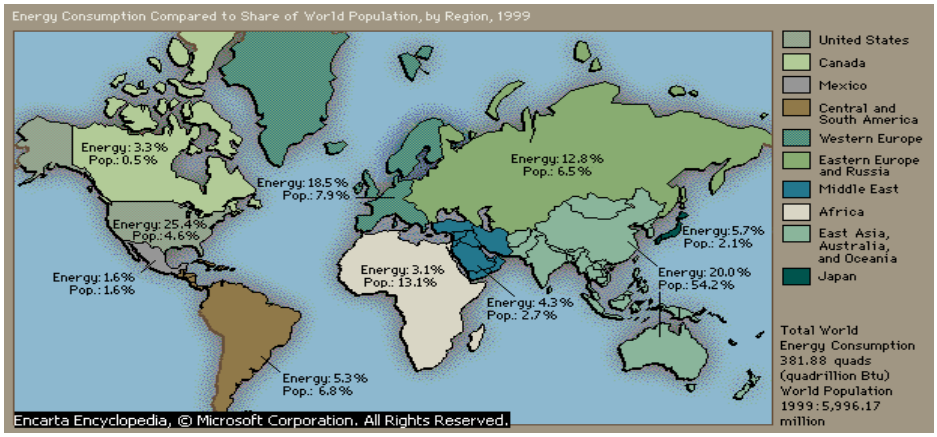
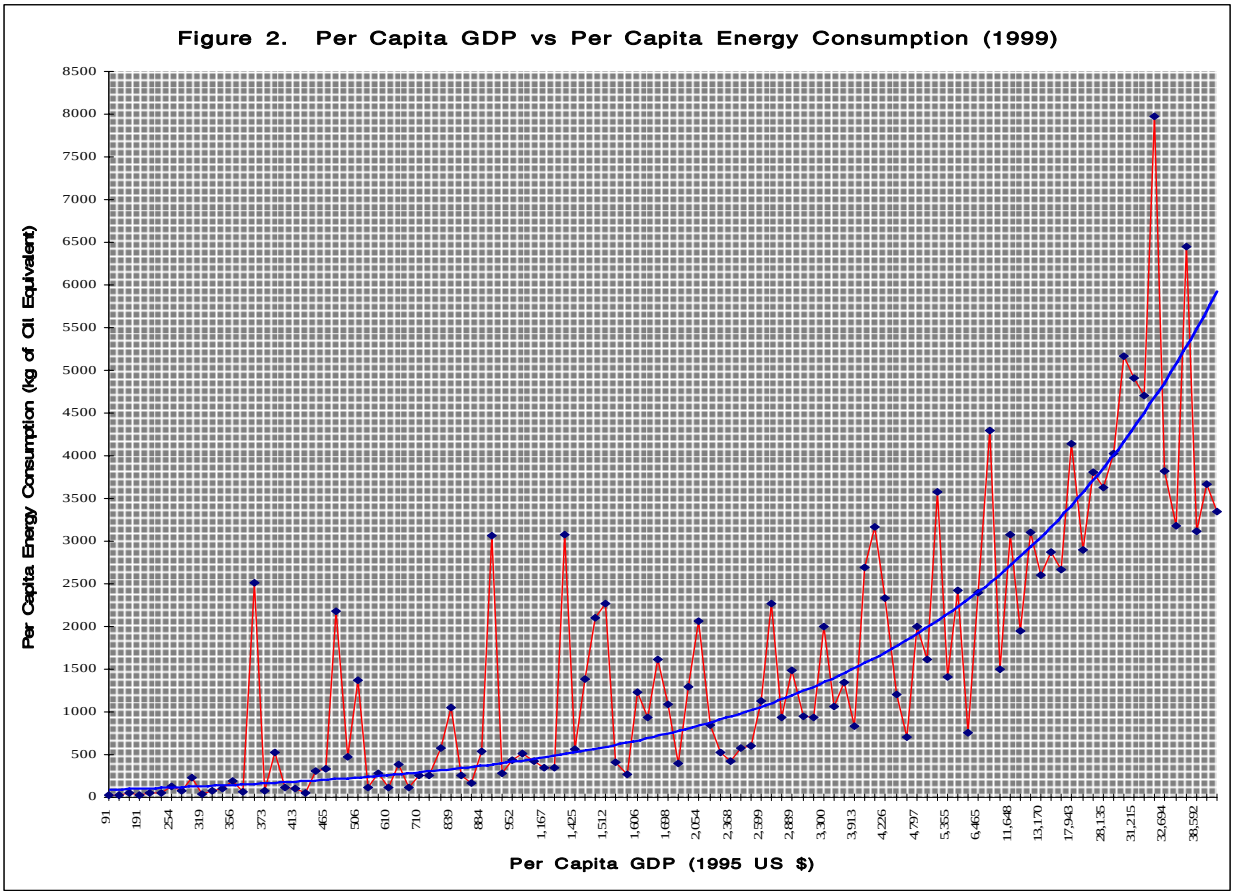


Figure 1: Map of world energy consumption comparing consumption of energy with population size [3].

Very much like what we have seen in Figure 2 with regards to the correlation between annual per capita GDP and annual per capita energy consumption of the 108 countries, there is a strong correlation between cereal yield and energy consumption as well. As can be seen from a study made on agricultural production and energy consumption [4], the higher the energy consumption the more the yield per hectare. Because of low energy input into the agriculture of least developed countries such as Ethiopia, their crop yield is low too. For example, if we take, among those countries with low, medium and high energy consumption, Kenya, Malaysia, and France, respectively, and compare their crop yield with that of Ethiopia, the picture looks like what we see in Table 1 below.

Table 1: Energy Consumption and Agricultural Productivity

Ser. No.	Country	Energy Consumption (kg of oil equivalent)	Agricultural Productivity (kg/ha)
1	Ethiopia	32	1,141
2	Kenya	98	1,434
3	Malaysia	2,005	2,860
4	France	4,030	7,271



III. THE POLITICS OF ENERGY (OIL)

Because of the crucial role it plays in economic and social development, energy has been accorded special consideration in the politics of the developed countries. Especially since 1859, when the petroleum (oil) era began, and since World War II, when petroleum accounted for the highest share of the energy consumption of developed countries, the importance of oil has gone beyond being just a matter of commerce. Oil has become an issue of political concern, leading countries to war and even occupying sovereign nations all in the name of democracy or some such other pretext, as we have only recently witnessed from what happened to Iraq.

To fully understand how the oil politics operates, it requires looking into the main forces involved and their alignments. As things stand presently, these forces can be classified into six; namely, international oil companies; governments of the countries of those oil companies; the rest of developed countries; former communist countries and China; petroleum-exporting developing countries, and petroleum-importing developing countries.

The powers controlling the production and market of oil are those international oil companies known as the "The Big Seven [5]." Of these, five belong to America, while the rest two belong to Britain and the Netherlands. Because these companies used to own oil wells in the Middle East (which account for 50 % of the world's oil deposit) and other areas, they had been the world's leading controllers of oil production and market before 1970, and the second leading beneficiaries since the establishment of the Organization of Petroleum Producing Countries (OPEC). Since the profits from the sale of oil amassed by these companies go directly to their home countries, the governments of these companies are the main beneficiaries, thereby being in a position to use oil as an instrument for serving their [political] interests.

The oil resources that the countries of Western Europe and Japan control are very small or virtually nil. Consequently, their role in the struggle for the control of oil resources is that of a loser. The constant increase in the price of oil in the world market has always hurt their economies and put them at a disadvantage. Because of the policy of self-reliance adopted by the former communist countries and China, Russia and China in particular, have especially managed to resort to locally available energy resources (e.g. coal, other fossil fuels and hydro power), and because they have managed to invest much in oil exploitation, they had become oil-exporting countries. However, with the exception of Russia and some of the former Soviet countries, all the other countries, including China, have become oil importers because of the recent changes. Even then, the damage caused to these countries due to the fluctuation of oil prices is minimal because the energy resources of most of these countries have been based on domestic resources.

Because of the different, overt and covert scheming tactics used by international oil companies, the developing oil-importing countries have been forced to rely on oil for their energy needs. Because, also, they could not develop their oil resources due to either lack of knowledge and capacity on their part, or guile or pressure on the part of the international companies, their fate in the scramble for oil resources has been one of expending the bulk of their hard earned foreign currency for the purchase of oil. For example, depending on the exchange rate, Ethiopia allots 36% to 55% of its annual export earnings for the purchase of petroleum products [6]. And this amount has now increased to 70% due to the recent escalation of oil prices.

The other issue that has now surfaced in relation to the energy and environmental politics is the refusal of the US government to sign the international agreement known as the *Kyōto* Protocol, which is aimed at reducing the amount of green-house gases emitted into the environment and causing global warming. Although the reasons given for such a refusal appear to do with something else, it is common knowledge that the actual reason behind the reluctance of the US government is not to harm the interests of the international oil companies.

An important lesson to be drawn from the above points is that oil (energy) is also an important political weapon and that making every possible effort to develop ones own domestic energy resources has a huge political advantage that goes beyond the economic and social benefits it entails.

IV. ENERGY RESOURCE DEVELOPMENT AND ACCESS IN ETHIOPIA: CURRENT SITUATION

The Ethiopian energy sector could be classified into two major sub-sectors: traditional and modern, or into four namely, (a) traditional

fuels and animate energy;[1] (b) oil and other fossil fuels; (c) electric power; and (d) modern renewable energy. The first type of classification is commonly used and without overlaps. This classification, however, has limitations in that it puts out of sight some of the major resource sectors. The second type of classification, although suffering from overlap problems (e.g. electric power and modern renewable energy), clearly corresponds with the situation in the country, while at the same time enabling one to identify the different sub-sectors. This type of classification is found to be more preferable than the first. The overview of the Ethiopian energy sector presented below, therefore, follows this classification.

4.1 The Stage of Development of Energy Resources

(a) Traditional fuel and animate energy

In Ethiopia, the major traditional energy resources consist of fuel wood, crop residues, animal dung[2] and charcoal. Aside from the fact that these energy resources satisfy most of the energy needs of the country, they are readily available and can be produced using traditional methods. However, except for the crop residues and animate energy, whose share is low, the main energy resources, that is, wood and its byproduct charcoal, are derived from forest resources which is increasingly diminishing (reduced to a mere 2.8% from what was 40%) [7]. As a result, the state of traditional fuel is on the road to destruction rather than development. It is public knowledge that our forest resource is shrinking, with the resulting degradation of the country's natural environment. And what makes the situation worse is the fact that there are no reforestation programs, and what ever there may be is not managed properly. As tempting as it is to tackle this issue, to delve into the details of the problem here would be a digression from the concerns of this paper.

Some thing that has not been given due attention as a source of energy, and yet one that is widely used in the agricultural sector, is animate energy. The Ethiopian agriculture and rural transportation are based on animate energy. Similar to dependence on traditional fuels, this is also a manifestation of backwardness. It might be argued that, because of the increase in human and animal population, the supply of animate energy has also increased. However, even though the head count of human and animal population has increased, as long as both humans and animals are underfed because of drought and lack of food and feed security, the argument that the animate energy supply has increased is invalid.

(b) Oil and other fossil fuels

All the oil that the country currently consumes is imported. The demand for it has also increased from time to time. The amount of oil products imported in 1992/93 was 555 thousand tonnes. This import had reached 1.1 million-tonnes mark by the year 2002, and had shown a two fold increase in a matter of just ten years [8].

On the other hand, however, although petroleum exploration undertaken so far has not yet shown result, it is known that the country has other fossil fuel resources. It has been ascertained that Ethiopia has a proven deposit of about 100 billion cubic meters of natural gas and over 200 million tonnes of coal [4]. Although efforts have been made over the past few years to develop these energy resources, and attempts are still underway, no concrete results have been achieved as yet. Moreover, it appears that the efforts on the part of the Ethiopian government are not based on a well thought out plan, not focused on human development, and are haphazardly managed. The fact that the exploitation of Calub natural gas deposit is still pending after so many years since the wells have been drilled and made ready for production, and yet, that there appears to be a conspiracy on the part of international energy companies, and the decrease in the support given to the Coal-phosphate Fertilizer Project, all seem to point a finger to the truth of the Government's reluctance.

(c) Electric power

Ethiopia has a lot of primary energy resources that can be used for the generation of electric power. What should be noted here is the fact that electric power can be generated not only from water but also from oil, coal, sun light, wind, etc. If we leave these sources aside for the moment and concentrate our attention on hydroelectric power[3], which is the energy source upon which Ethiopia relies in the main, according to the available data, Ethiopia's potential electric power is in the range of 15,000 to 30,000 Mega Watts (MW) [9]. And yet, what has been developed so far amounts only to 663 MW, [10] or only 2% to 4% of the total potential. And of this, the share of small

[1] Animate energy includes that of humans as well.
[2] Animal dung includes excreta of donkeys, mules, horses, etc.
[3] Of total electric power generating capacity of 706 MW in 2004, 94% or 663 MW were from hydro, while the remaining 43 MW were largely from diesel and, to a limited extent, from geothermal resources.

hydro power is only 6.5 MW, or 1%. Primarily, development of small hydro power plants should have been encouraged as they could be developed without any need for foreign loans and by using the country's own manpower and material resources.

(d) Modern renewable energy

Modern renewable energy resources include all renewable energy resources other than traditional fuel resources. Accordingly, ethanol derived from plants, biogas, water, sunlight, wind, geothermal deposits and hydrogen derived from renewable resources all constitute modern renewable energy resources.

Ethiopia is especially blessed with hydroelectric, solar and geothermal renewable energy resources. As has been pointed out earlier, its potential of hydroelectric power resource is enormous. In addition to this, because Ethiopia is geographically situated in the tropics, it gets a lot of annual sunshine and longer daylight. Therefore, it is blessed with a lot of solar energy. When it comes to its geothermal energy resource, there are studies indicating that the country is one of the richest in the world. Studies by Jack Varet [11] and other scientific research findings have confirmed that Ethiopia could generate 700 MW of energy from its geothermal energy resource alone.

Unfortunately, however, the sad fact is that there isn't any renewable energy resource that has been developed, or the development of which is underway at present, other than big hydroelectric power plants. Of the geothermal energy resource available, only 7.3 MW of power is developed so far [10]. Because renewable energy resources do not cause environmental pollution and climatic change, as is the case with oil and coal, it is believed that they would be the main energy sources of the 21st century, as a result of which both the developed and the developing worlds have given due attention to their development and exploitation. In countries like Ethiopia, where the great majority of the population live in rural areas, it is only by constructing small-scale power plants that one could provide electricity to every household or village. For this purpose, none is better suited than renewable energy resources. It is possible, for example, to provide rural areas with electric power using solar lanterns (See Figure 3 below).

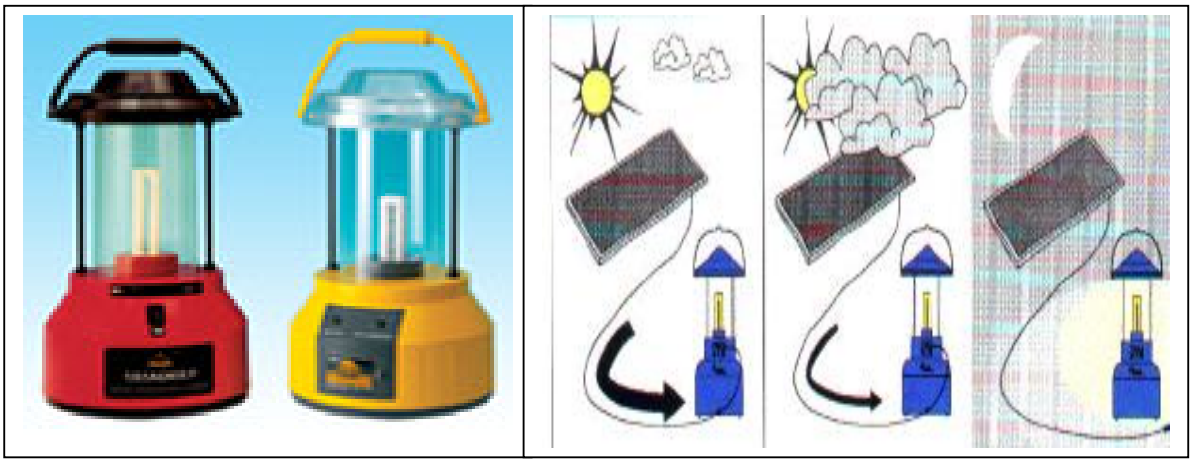


Figure 3: Solar lanterns that can be used in rural areas located far away from electric power lines

Similarly it is possible to use solar water pumps for the supply of potable water for humans and animals, and also for irrigation. It is also possible to use solar stoves for cooking food, and solar water heaters that can be mounted on rooftops for heating water (See Figures 4, 5, 6 and 7 below).

Figures 4, 5, 6 and 7: Solar water pumps for use by humans and animals and for irrigation; solar box cooker; and solar water heaters to be mounted on rooftops.

Given all this potential, however, there is no project dedicated to the extensive development of renewable energy resources, except for the sole pilot project undertaken by the Ethiopian Rural Energy Development and Promotion Center. Neither the Federal Government nor the Regional States have yet given this issue the attention it deserves. The Ethiopian Electric Power Corporation (EEPCo) has been and is still supplying electric power to rural towns using diesel generators [10]. Similarly, the new project, which provides schools with plasma television, uses diesel generators, although it only requires small power. Both EEPCo and the Government have focused their attention on using hydroelectric power and diesel generators to meet the country's electric power needs. Such things as the appropriate energy mix and environmental protection do not appear to have attracted any attention yet.

Appropriate energy mix should be accorded serious attention, considering the recurrent drought and the power shortage we have been facing in the last two or three years. As pointed out earlier, the fact that 94% of the country's electric power generation relies on water resources is a clear indicator of the serious crisis the country would have faced had protracted drought set in. Consequently, of the electric power plants we have, some of them must use energy resources other than water. The readily available natural gas, geothermal, coal and wind energy resources would make a good substitute. The fact that, of the said resources, only geothermal energy resource has only been tried modestly is a clear indicator of the fact that very little indeed has been done with respect to developing the said energy sub-sector.

So far we have looked into the state of energy resources development of Ethiopia, it is now appropriate to look into the extent of energy consumption and access and compare with those of other countries.

4.2 Energy Consumption and Access

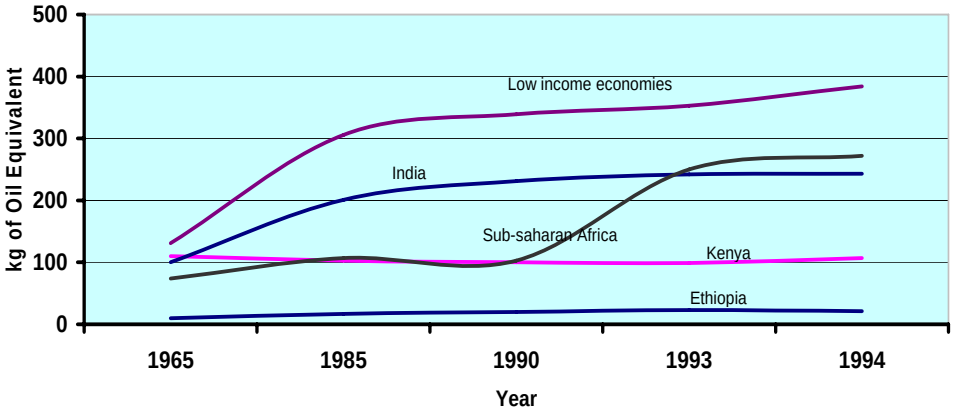
Similar to other countries with low-level of economic development, traditional fuels take the largest share of energy consumption in Ethiopia. As studies have indicated, traditional fuel consumption in Ethiopia accounts for 94.5% of the total [12]. While this is too high when compared with other countries, it is at the same time a clear indicator of the backwardness.

The share of oil and electric power in the energy consumption of developed countries is extremely high. As such, the consumption of these resources is regarded as indicator of economic development and modernity. The share of oil and electric power in the energy consumption of Ethiopia is only 5.5%. Of this, the share of consumption of electricity does not even come up to 1%. Although the share of these modern energy sources is low in Ethiopia, the role they play in the modern economic sectors, that is, industry, transport, construction, mining and services is so big, as they are the major driving forces of these sectors.

The share of modern renewable energy in the Ethiopian energy consumption is so low that they are hardly in need of accounting for. The attention given to these energy resources is equally low. At this juncture, I think it is important to raise a rather sad situation. The ethanol plant of the Finchaa Sugar Factory has the capacity to produce 8 to 12 million liters of ethanol annually for use as fuel for vehicles [13], [6]. Ethanol is a renewable fuel, which is widely used by such countries as Brazil and the U.S.A. And yet, because of the little consideration oil companies give to national interests and, also, because of the ongoing dispute between the Government and the oil companies, this renewable fuel has not been used for vehicles beyond experimental level. Molasses, which is a by-product of the sugar factory and, also, the raw material for the production of ethanol, has disturbed the sugar production and it is drained into a stream as a waste after treatment.

In general, the consumption of modern energy is extremely low in Ethiopia. The fact that the Ethiopian rural areas have no access to electricity, like the old times, is a big and sufficient evidence for this sad state of affairs. Ethiopia's per capita energy consumption in 1994 was a mere 21kg of oil equivalent [14]. When compared with the per capita energy consumption of sub-Saharan African countries and that of the other low-income countries, this amount is extremely low. When especially compared with the consumption level of neighboring countries such as Kenya, it is less than 20%. When compared to the average consumption of sub-Saharan Africa, it is only 8% to 6% (See Figure 8 [14]). If the comparison is made with developed countries, the modern energy consumption of Ethiopia ranges between 0.4% and 0.5% (See Figure 2).

Figure 8- Per Capita Consumption of Commercial Energy for Selected Countries



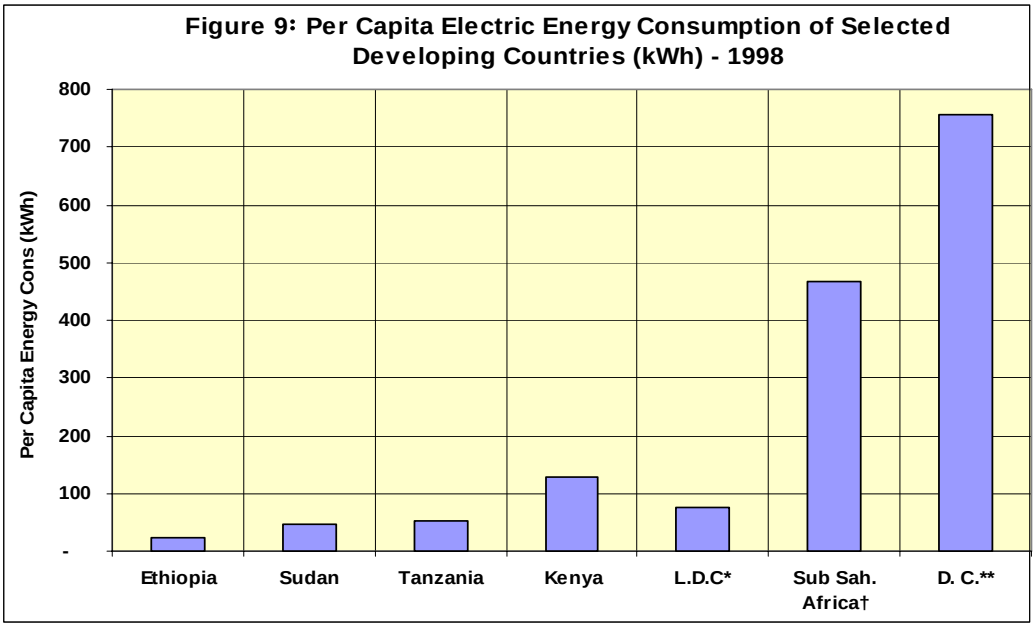
Considering electric power consumption, Ethiopia's per capita consumption in 1998 was only 24 kilo Watt hours (kWh). By contrast, as shown in Figure 9, the per capita consumption of the Sudan and Tanzania was double that of Ethiopia, while that of Kenya was five-fold, that of the least developed countries three-fold, that of Sub-Saharan African countries twenty-fold, and that of developing countries 32-fold. This shows extreme underdevelopment and also is very disgraceful.

When we consider the matter from the perspective of access to modern energy, the number of people that have access is very low in Ethiopia. It could be said that the majority of the Ethiopian rural population (73% in 1996) use only kerosene from among the available modern energy resources, and even then, only for lighting. Moreover, when compared with the overall energy consumption of the country, the share of kerosene consumption of the rural population does not even amount to 1% [14].

The same holds true when it comes to access to electric power. Access to electric power, as projected for the present year (2005) by the Ethiopian Electric Power Corporation, is 17% [10]. In developing countries, such as India, most of the states have 100% access to electricity, while those states considered as having the least access have reached at 75%.

Growth of energy access creates a lot of economic opportunities. It saves the time spent on gathering fuel wood, cow dung and grain grinding, and also for fetching water and similar activities. In addition to providing lighting, electricity could be used for running drinking and irrigation pumps, operating cottage industries, and equipment in the health and education institutions in the rural areas and thus enhances development. As we may note from this and the experience of other countries, the very low access to electricity in Ethiopia has contributed a lot to the sustenance of poverty prevailing in the country. Therefore, one of the key measures that need to be taken to reduce poverty is to increase access to electricity in all parts of the country including the rural areas.

Before concluding our discussion of the present status of energy resource development and energy access, a cursory glance at the institutional arrangement and the energy master plan would help us understand the general organization and orientation of the Government regarding the sector.



Note: *L.D.C. = Least Developed Countries average, **D.C. = Developing Countries average, †Sub Sah. Africa = Sub Saharan Africa average

4.3 Energy Institution, Policy and Master Plan

(a) Institutional arrangement

Since the last four years, the energy institutions under the Federal Government have been organized in a rather fragmented manner [15]. According to the current organization, the responsibility of managing rural energy development has become that of the Ministry of Agriculture and Rural Development. And under this Ministry, the body responsible for energy is the Ethiopian Rural Energy Development and Promotion Center, an institution which was formerly under the Ministry of Mines and Energy. The responsibility for managing the modern energy sub-sector is mainly given to the Ministry of Infrastructure. It has under its direct supervision the Ethiopian Electricity Agency, EEPCo, and Petroleum Depot Administration. While the responsibility of overseeing the development of mineral energy resources has gone to the Ministry of Mines, the body responsible for supervising and controlling fuel trade and oil companies is the Ministry of Trade and Industry. What one concludes from this organizational arrangement is the fact that there is not one single government institution with a comprehensive power to oversee, plan, coordinate and direct the energy development and management of the country. Given the current situation, there is no government institution to look after and guide the future direction of the fuel energy development of the country. In short, one could dare say that the Ethiopian energy sector has no one to look after it in a comprehensive manner. This kind of arrangement is completely different from what one sees elsewhere both in the developed and the undeveloped countries. The other countries and one can say all of them, have government institutions known either as the "ministry of energy" or "ministry of energy and mining." (One can easily access this information from the Internet.)

On the other hand, currently EEPCo is the sole modern energy generating company in the country. Although Finchaa Sugar Factory produces fuel ethanol, which is not yet on the market, it is of no visible significance. Similarly, there are a few micro hydroelectric power plants built by non-government organizations such as Mekane Yesus Church, the capacities of which do not go beyond serving small local communities. The significance of these plants is not considerable as well. Such situations have badly hampered the development of the sector. A few petroleum-distribution companies have recently joined the energy market as the result of a measure taken by the Government to abolish fuel distribution monopoly. This is a good beginning indeed. The growth and development of the power sector could be accelerated if power generating companies other than EEPCo were allowed/ encouraged to operate in the country.

(b) Policy and master plan

When it comes to policy, Ethiopia has had its own energy policy since 1994 [16]. This, too, is a good beginning. However, since quite many of the issues entertained in the policy have not been implemented, it appears that not much attention has been given to the policy. It also appears that the policy has no implementing body. On the other hand, because of the organizational problems pointed out above there is no single institution responsible for the energy sector. Consequently, there is no draft or approved master plan that guides the development of the sector. The only master plan one can speak of is the 25 year plan prepared for the development of electric power. And because this plan relates only to EEPCo and does not take into account the energy sub-sectors outside of electricity, it would not enable us to see future from where we stand today.

4.4 Energy Efficiency and Services

As there are problems with energy supply or access in Ethiopia, there are problems with efficient utilization of energy as well. If we consider the utilization of the traditional fuelwood, we see that the traditional stove consisting of three *gullicha*[4] wastes a lot of fuel; its efficiency does not exceed 10%. In the past few years, however, efforts have been made by the Ethiopian Energy Development and Promotion Center and the German Development Cooperation (GTZ) to produce and disseminate improved wood and charcoal stoves. While this is a commendable step, there still remains a lot to be done in the area of making the stoves widely available. If the effort is extended on a sustainable basis, over and above helping to reduce the

[4] *gullicha* is a vertical clay gadget tapering towards the top, three of which are placed with equal distance between them to support cooking utensils over the fire. The three form what is equivalent to *stovetop* or *range,* in American English, or *bob,* in British English.

destruction of forests, it will also prevent a number of health problems, respiratory infections associated with exposure to smoke from fuel wood.

As has been pointed out above, the main producer of modern energy is EEPCo. As commendable as its recent efforts are, EEPCo, however, has a big problem of efficiency when it comes to power distribution and service provision. The Corporation does not appear to have given due attention especially to energy-saving equipment. For example, according to a study undertaken by the Ethiopian Network for Sustainable Energy Development (ENSED), an energy advocacy association established two years ago, by replacing the currently used incandescent lamps with energy-efficient compact fluorescent lamps (see Figure 10) it would be possible to save electric power amounting to not less than 100 MW [17]. Unfortunately, the issue hasn't got the attention it deserves yet. It is also possible to save a lot of energy by employing energy-saving equipment and processes, and applying proper energy management practices in factories and other enterprises. However, as the desired due attention has not been given to the problem yet, we see a lot of energy being wasted all around us.

Figure 10: Compact fluorescent lamp that can save energy by about 80%

4.5 Energy Technology Transfer and Development

Technology transfer and development in Ethiopia is pitiably frail. What is even more pitiable is the fact that the effort exerted on capacity building and local development of technology is very low. Especially, the effort made to build local technological capacity in the energy sector is weak. For instance, in the last 50 years, EEPCo could have developed a big capacity in power plant studies, design and construction, and also in equipment manufacturing activities such as that of transformers. Nevertheless, because the issue has still been denied the attention it deserves, the Corporation is still importing these services and equipment. EEPCo once had its own training center. That too is now closed.

When we turn to higher learning institutions, it is known, for instance, that Addis Ababa University runs post graduate programs in electrical and mechanical engineering. This, too, is a commendable step forward. However, there are no extensive research and design development projects being undertaken. And no budget has been allotted for these purposes either. In generally, it should be noted that the science and technology of a country cannot be developed by purchasing them from abroad. Accordingly, giving due attention to the problem and building research institutions as well expanding and encouraging technology transfer and development activities is something that should have been encouraged all along.

V. WHERE WOULD ETHIOPIA BE IN 2020 IF THE CURRENT SCENARIO WERE TO CONTINUE?

In the previous sections, it has been attempted to show the current status of energy in Ethiopia by using certain indicators and comparing the situation with those of other countries. In the following sections attempts have been made to predict or project what the energy status of Ethiopia would look like by using current figures with past growth rates and taking into account some possible changes that might occur in the future. It is found more appropriate to describe the scenario in terms of the four energy sub-sectors indicated in the previous sections.

5.1 Traditional Fuels and Animate Energy

In the coming years, with the increase in population size, the demand for the major traditional fuel, wood, would continue to increase. This, coupled with the expansion of agricultural land and the construction sector, would result in the destruction of the unprotected natural forest and its replacement with agriculture. Because of this, such rural activities as *cutting* or *gathering* wood from forests could cease completely. According to the projection made in a study made by Aleazar Tilahun, all of the existing natural forests of the country will be wiped out by the year 2027, if the current trend continues into the future [18]. But it must be made clear that this does not mean that the country will be completely

devoid of all wood species after the indicated year; rather, it means that the southern and western regions of the country, which currently have natural forests, will be like the rest of the country that have lost their forest resources. There will still be trees planted in backyards and protected zones as well as wild bushes, and these shall become the main source of supply of traditional fuels. Even then, traditional fuels will continue to have a high share in the energy consumption of the country. However, this share shall gradually diminish as a result of the development of other sources of energy.

On the other hand, among the traditional energy sources, crop residue and animal dung can serve as fertilizers. However, at the moment they are mostly used as fuel. The removal of these resources from agricultural land has devoid the land the organic fertilizer it would get from these materials. As the result the agricultural land has lost its fertility. Moreover, because of the land degradation resulted from loss of forest cover, soil erosion has become a major problem, and all this has adversely affected the agriculture. If the current situation continues, there could perhaps ensue a considerable loss of agricultural production because of the mismanagement of these energy sources.

5.2 Oil and Other Fossil Fuels

If demand for oil products of Ethiopia increases at the same rate as in the past years, the consumption of these products will increase from the current 1.2 million tonnes to 10 million tonnes per year by the year 2020 (E.C.). However, due to the increase in the price of oil and the problem of global warming, or climatic change, using oil will become increasingly difficult. The increase in the price of oil will prove to be especially burdensome to Ethiopia's economy, as the country happens to spend more than half of its foreign currency earnings for the purchase of oil products.

On the other hand, however, since oil is necessary in order to bring about rapid growth in economic development, there ought to be alternative means of supply. In this respect, then, we need to use the natural gas, coal, ethanol and other renewable energy resources available to the country. Moreover, as I have pointed out in another study [6], we need to make changes in our mode of surface transportation and our energy consumption regime. As things stand now, most of our import and export commodities (92%) are transported by trucks instead of train, whose energy consumption per tonne-kilometer is very low. When we consider the global situation, one train compares to 30 trucks in terms of energy consumption per tonne-kilometer. This shows that the undue neglect of the Ethiopian rail transport system has indeed heavily hurt the economy of the country. Not only that, the damage will continue with an even greater magnitude unless rapid changes are made soon.

Another way to reduce the oil consumption is to convert train and city buses to those driven by electricity (See Figures 11 and 12). Increasing the utilization of electric trains and trolley buses, aside from helping reduce our oil consumption, will also reduce our expenditure on spare parts and other costs. However, as things stand now, we don't appear to think of any alternative other than continuing to purchase oil products. Unless this orientation of ours changes quickly, even the economic growth rate we now maintain may slow down.

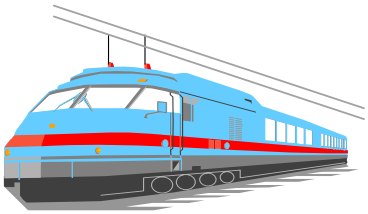


Figure 11: Electric train

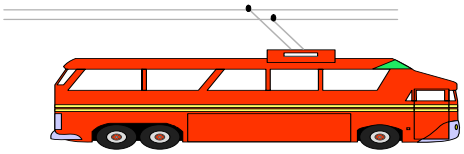


Figure 12: Trolley bus (electric city bus)

5.3 Electric Power

While the current per capita electric power generating capacity of the country is about 10 Watts, the annual per capita electric energy consumption is 28 kWh according to EEPCo's estimate [10]. Let us see what this per capita electric energy consumption means with the aid of an example.

Let us say that each of us in this hall has ten lamps at home, each with a 60-Watt power rating. Let us say that we turn on the light from 6:00 p.m. to 11:00 p.m. every day, which means that each of us will consume 90,000 (= 60x10x5x30) Watts, that is, 90 kWh of electric energy per month. Please note that this does not include the power we use for baking, cooking, refrigeration and ironing. Had there been equal distribution of all electric energy generated in the country, the audience gathered here tonight would have finished our consumption quota for the next 3.2 years (=90÷28=3.2 years) within a month and we would be condemned to live in total darkness, with no electricity available, for the next 3 years and two months. If, on the basis of this hypothetical quota regulation, we were denied the use of electric power for the next 3 years and 2 months, what would each of us feel? Our citizens who actually live this life-in-darkness that I posed for you to imagine living, not just for 3 years and 2 months but all their lives, constitute 85% of the total population. We can realize how much unjust it is to allow this state of affairs to continue unchallenged.

The electric power generating capacity of Ethiopia during the last days of Emperor Haile Selassie was only 260 MW. During the 17-year reign of the Dergue, that capacity increased by a mere 153 MW. When we add to this the 293 MW installed during the last 14 years, we find the country's electric power generating capacity currently standing at 706 MW. When we consider the last 31 years, the total increase is 446 MW. Computed in annual terms, the increase has only been 3.3% per annum. If the current trend continues, the power-generating capacity of the country would reach only 1,482 MW by the year 2020 (E.C.), or only double what the country generates at present. This prospect is not the kind that would help us extricate the country from the backwardness it finds itself in at present.

According to the master plan study prepared for EEPCo three years ago, the electric power demand of the country will be 2,335 MW, or 9.9 million Mega Watt hours (MWh) by the Year 2025 [19]. The population of Ethiopia is projected to reach 117.6 million by the same year, so that the per capita electric power consumption will be 84.2 kWh. Compared to the current consumption level, this figure represents a 3-fold increase. Still, the figure is less than two-thirds of the energy currently consumed by our neighbors, such as Kenya, for example. This, then, is a clear indication of the fact that maintaining the current trend does not take us out of our backwardness or the poverty the country wallows in.

5.4 Modern Renewable Energy

It has already been pointed out that the development of modern renewable energy, other than hydroelectric power, is so far insignificant. We have a lot of streams that are flowing all the year round and could be harnessed for small hydroelectric power generation; we also are graced with "thirteen months" of sunshine; we have the largest cattle population in Africa, whose enormous dung could be used for biogas production. And yet, because of very low development work in this area, the rural areas of the country still live in darkness, just like the old days. If all the waste and trash gathered from each household in urban areas were appropriately utilized, it could have proved another source of energy instead of being a source of environmental pollution.

However, since the last two years, there is an extensive and promising program initiated and being undertaken by the World Bank and the Ethiopian Rural Energy Development and Promotion Center. Based on the Program, an institution named Rural Electrification Fund has already been established. The activities of the Fund are geared toward providing loans and professional support to rural electric power developers, investors and cooperatives. If the project is successfully implemented, numerous hydroelectric, solar and wind power plants can be constructed in many rural communities within the next twenty years. It is estimated that the capacity of these plants could grow to 300 MW in 20 years. If things turn out to be to the contrary, however, we will not be moving anywhere.

5.5 Overall Energy Consumption

In the foregoing sections, it has been attempted to show the extent of development that could be

achieved in the area of the different energy resources. The cumulative effect of these different resources could increase the annual per capita energy consumption of the country to the equivalent of about 93 kilograms of oil equivalent. Compared with the energy consumption volume of other countries, this amount is very low even at present, let alone 23 years from now.

VI. VISION FOR THE ETHIOPIAN ENERGY SECTOR IN 2020 (E.C.)

To project 23 years into the future from where we are now is difficult, for the time range we are talking about is remote. I had therefore found it difficult to find answers for the dual question of what Ethiopia's energy sector could look like and what it ought to look like in the year 2020 (E.C.). However, based on the experiences of other countries as well as a vision of bringing about a much faster economic growth than the present, I have tried to proffer my visions, which I shall do in terms of the energy sub-sectors enumerated in the previous section.

6.1 Traditional Wood and Animate Energy

It is envisaged that the problems created by the diminution of our forest resources will gain high recognition both by the Government and the public. Accordingly, a variety of policy measures will be taken and bring about changes. For example, the right to ownership and development of trees shall be recognized through appropriate policies; this will encourage planting of trees, with the result that it will improve the utilization of the current household fuel consumption, which is adversely affecting the country's forest resource and agricultural productivity. In addition, through extensive use of biogas, distribution of improved stoves, utilization of coal and other new energy resources for household use, the mode of consumption of traditional fuel shall be improved, and its share in the energy consumption shall also be reduced.

As the result of increase of agricultural productivity in many manifolds, the amount of crop residue shall increase in the same proportion so that there will be surplus crop residue enough to meet the fuel needs of households after putting what is needed for maintaining the fertility of the soil. Because increase in agricultural productivity would mean increase in the income of farmers and owners of cottage industries, many rural areas will use modern energy sources such as electricity and biogas. Since, in the course of the projected range of time, training and education on the judicious gathering and utilization of fuel wood will be given to the people, supplementary fuel wood can be made available without risking destruction of forests. Because of all these reasons, in the year 2020 (E.C.), traditional energy supply will be managed in a sustainable manner without any adverse effect on the environment. As a subsequent result of this, the year 2020 (E.C.) shall witness a reduction in the diminution trend of forest resources and an increase in reforestation. Since for the reasons mentioned above the forest resource of the country will regenerate, the area covered by forests will increase from the current 2.8% to over 6.0 %.

6.2 Electric Power

If, according to Dr. Birhanu Nega's estimate [20], urbanization increases (to 40%), economic productivity (both urban productivity and that of the peasant) improves, and if the rate of population increase falls by 0.4% from the current rate, the annual per capita income of Ethiopia could rise to about Birr 1,623 by the year 2020 (E.C.). As this figure is based on the 1980 constant price, it would come to USD 784. When we look at the per capita income and energy consumption chart of countries shown towards the beginning of this paper, this income corresponds to 260 kilograms of oil equivalent modern energy consumption. In terms of the population size in the projected year, this corresponds to the overall modern energy demand of 30.6 million tonnes of oil.

The overall electric energy consumption of Ethiopia in the past years constituted 10% to 15% of the total modern energy (oil and electricity) consumption. If we assume the future average consumption to be 10% and we use the above calculation, a demand corresponding to 3.9 million tonnes of oil equivalent, or a 36.18 million MWh, or 8,615 MW generating capacity would be required by 2020. Since 8,615 MW means 12-fold the current capacity, it represents a great leap. Even if we take into consideration those power plants studied to-date and others under consideration, we can only achieve 2,500 MW. For this reason, if the

economic growth envisioned by Dr. Berhanu Nega becomes a reality (and my vision is that it will), the rate of our electricity-generating capacity should grow not at the current, sluggish pace of 3.3% but at the rate of 11.5% per annum.

My vision is that by the year 2020 (E.C.), 40% of the energy generated from our electric power plants will be obtained from those resources other than hydroelectric power.

6.3 Petroleum

If, once again, we base our projection on Dr. Birhanu Nega's vision of economic development, assume that the growth of this energy sector would follow the trend of other countries, and also assume that the share of oil consumption would on the average be 90% of the total modern energy consumption as in the past years, Ethiopia would need 27.5 million tonnes of oil in 2020 (E.C.). When this is compared to the current volume of consumption, it represents a 23-fold increase, which is quite a leap. Considering the current global attempt to switch to other sources of energy due to the inflation in oil prices and the problem of global warming, it would be difficult to meet the oil demands of the projected year. There is, therefore, a need for a radical policy change. Any such policy change must have as its focus developing the proven fossil fuel deposits and changing the current type of surface transport system and the kind of energy it consumes. As has been discussed earlier, it would be possible to substantially reduce the demand for petroleum by expanding rail and city bus transportation and converting both into electrically operated systems. If we follow this trend, in addition to being used for fertilizer production and for household consumption, natural gas could cover 15% of the modern energy consumption of the country by the year 2020. Rail and city bus transportation will expand, and the share of electric train in transporting goods will at least reach about 30%, while about 30% of the city buses will be driven by electricity. This is my vision for the Ethiopia of 2020 (E.C.).

My other vision is that, if fuel ethanol and biodiesel programs are reformulated and expanded and some preliminary work is undertaken to shift toward the hydrogen economy[5] that the rest of the world is moving to, the energy demand of the projected year will be met.

6.4 Modern Renewable Energy

Although these energy sources can serve the needs of both the rural and urban areas, they are more suited to the former. Besides, they can be easily developed. Taking this into consideration, we can make the following projection. In 2020 (E.C.), 30% of the Ethiopian rural areas will have access to electricity generated from solar, water and wind sources. Of course, it is obvious that this vision cannot be realized by maintaining the current pace of development. It requires undertaking various training and research activities, equipment manufacturing and undertaking similar development promotion programs, as well as establishing extensive credit schemes in the rural areas. It would also be useful to learn from the experiences of other countries and establish energy cooperatives, such as those done for the agricultural sector.

6.5 General Considerations

In 2020 (E.C.), Ethiopia will have a full-fledged Ministry of Energy that have been established in advance of the projected year, and one that would be responsible for making sure that the sector will have the capacity to realize the above-mentioned goals. The Ministry shall have numerous institutions under its jurisdiction, each with its own specific functions. The Ministry will coordinate all energy-related activities, draw up a master plan, monitor plan implementation, develop energy technologies by allotting special budget for technology transfer and development, build up the human capacity of the sector, and undertake research in collaboration with universities.

In 2020 (E.C.), all households and institutions in Ethiopia will use energy-saving lamps and other equipment. Preventing waste, or the efficient use of energy, will be part of the people's culture. There will flourish healthy and efficient interaction between service providers and their clients. I, therefore, have a vision that all these would serve to improve the living standards of the people.

Unlike what we see today, there will emerge numerous power

[5] Hydrogen economy refers to the kind of economy created by replacing petroleum and other fossil fuels with hydrogen. Because of the fact that fossil fuels are not renewable, are causing global warming and their deposits are on the decline, it is believed that the fuel for the 21st century would be hydrogen. The developed countries have initiated extensive programs for the realization of this economy.

companies in the sector other than EEPCo**.** The quality of the services they provide will be up to the standard and to the satisfaction of consumers. Ethiopia, then, will join the ranks of those countries with high level of energy access.

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