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ISSUE PAPER ON BIOMASS UTILIZATION AS SOURCES OF ENERGY IN AFRICA

AUGUST 1980

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AS SOURCES OF ENERGY IN AFRICA

I - Introduction

1. For a long time the economic parameters for development of a country were considered as land, labour, capital. Recently, the energy has joined these parameters of measurements. The energy has had its own influence since longtime ago on any development programme but has been given less attention from any of the planers because of its very low price and plentiful availability. The price increase of one petroleum barrel from 1957 to early 1973 was about 0.75 cent/barrel to 1.25 US Dollar/barrel while immediately after 1973 the price has boomed to 12.75 US Dollars/barrel to approach in 1980 about 35 US Dollars/barrel. The price increament recorded a very sever jump as shown in fig.1

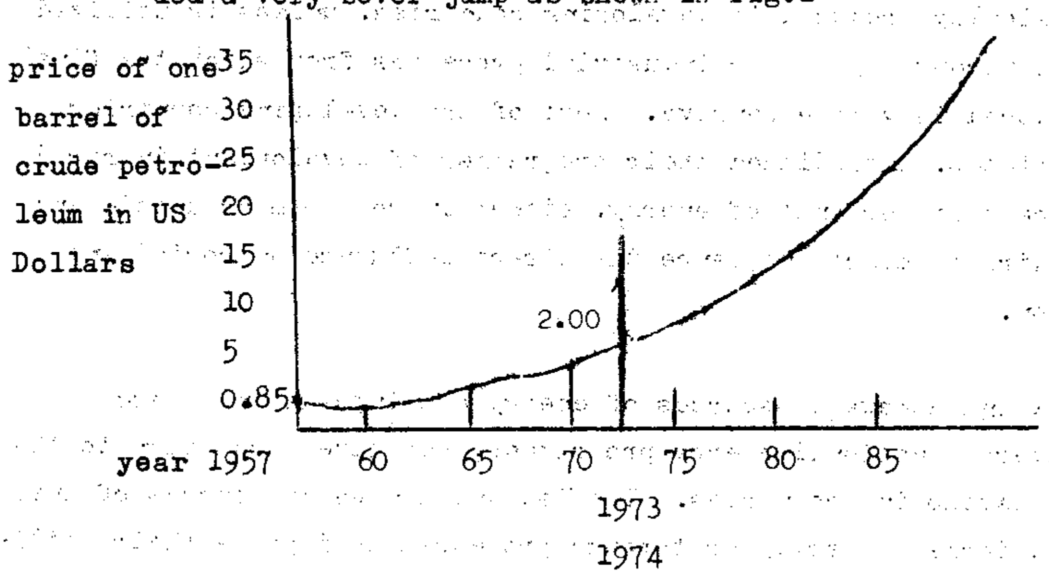

Fig.1 Increase in petroleum prices between 1957 and 1980 (Average value)

2. The developing countries suffered from this sever increase of fuel costs which in some cases absorbs more than 50y of National income. This problem has a direct impact on the development programme in these countries. The energy in whatever form, is vital and necessary for development. The most classical and traditional form of energy which has been settled for long time is the transformation of fuel energy into electricity through thermodynamic cycle. Whenever the electric energy appears, it will become soon developed.

3. The developing countries have just started to implement their development programmes to accelerate the improvement of the economical and social standard of their nation. Unfortunately, the booming of the energy prices (either in row form or industrialised) created a big invelence of these programmes. Fossil fuels, which is basically produced in developing countries, unless is utilized has to be processed through system or industrial processes from which the final cost of energy produced is very expensive. Most of the developing countries including African states, established their programmes of development in rural areas, but the price cost per unit of energy, either in row form or usable and using form, has a direct impact and hence the direct influence on social and economical situation.

4. The use of New and Renewable sources of energy and integrating these sources into the overall national energy programmes, may give a solution to the development of the developing countries. The New and Renewable Sources of Energy may be used in many forms (directly or through processes to improve their utilization). Different forms of New and Renewable Sources of Energy include:

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- Solar Energy and its relationship to all N & R Sources of Energy
- Wind Energy
- Hydropower, through water falls, water streams, ocean tidal, waves, currents, etc.
- Geothermal
- Ocean water temperature difference.
- Biomass (including fuelwood and charcoal) with biogas as its byproduct

A. Biomass as a source of energy

5. Among all of these New and Renewable Sources of Energy the objective of this paper is the biomass, including fuelwood and charcoal as a source of energy in Africa. All developing countries including African States have been using biomass as a primary source of energy and many are heavily dependent on it. It is estimated that 2000 million of the world population depend on fuelwood and residues for their primary energy needs. Biomass is the all organize matter produced by plants, animals and micro-organisms including trees and shrubs, agricultural crops and corp residues, grasses, aquatic plants, animal wastes, urban garbage and the by-products from forestry and agricultural industries, solar energy is the key factor in the production of plant biomass. Through the process of photosynthesis, plants are able to convert the carbon dioxide and water into organic material and oxygen. Thus the plants are able to capture the solar radiation and store it for future use as biomass. In the developing world, the magnitude of using biomass has been increased and it is estimated that about an equivalent of 20×10^6 barrels of oil per day are substituted by biomass. This use is mostly confined to developing countries. The effects of overuse of biomass pose serious problems with long term consequences.

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6. During the last five years (please refer to fig.1) three consequences related to biomass energy use and oil/energy problem have been observed:

a. In developing countries there is a trend to accelerate production of fuel from biomass as fossil fuel products have become very expensive and unavailable.

b. In developed countries large efforts on research and development programmes have been instituted to establish the potential and cost of energy generated from biomass but the work is still at the early stages. Demonstration projects and small scale commercialization are being rapidly implemented.

c. In certain countries, large scale biomass energy schemes are being now implemented as rapidly as possible at a current investment of over half billion dollars per annum.

B. Utilization of biomass for biogas production

7. The developing countries have a population of about 3 billion of which about 70 percent are lining in rural areas. Africa is one which has the proper and good situation for biogas production and utilization. Biomass as source of energy in rural areas usually supplies more than 85 percent of the energy needs mostly used for house hold requirement, such as cooking. The main issue in developing countries is that of scarcity and the problem of trying to maintain or to increase the present level without harming agricultural or forestry and as a whole, the ecological system. Africa has been utilizing about 65 percent of the total energy consumed, through biomass and its derivatives.

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8. The availability of biomass in Africa comes from four sources:

a) Agricultural and forest residues

b) Existing standing vegetation

c) Crops specially grown for convertion to useful fuels

d) Animal, human and industrial wastes

The estimated annual production of Dung and its energy content in developing countries including Africa are shown in the table 1. The figures in this table is based on the ESCAP 1980 and the amount of the manure produced varies according to the weight of animal amount and nature of animal feed. The values given here are average values nearly representative to conditions in developing countries in general.

Animal	Amount in Developing countries million heads	Fresh manure production/head kg/year	Calculated amount of manure t/y	Estimated Biogas Production m^3/y	Energy Content Kcal **
*Cattle	685	5400	$37x10^8$	$11x10^{10}$	$5.8x10^{14}$
*Buffalo	99	7000	$6.93x10^8$	$2x10^{10}$	$1.12x10^{14}$
*Horses & Mules	73	1700	$1.24x10^8$	$0.4x10^{10}$	$0.21x10^4$
*Camels	13	—	—	—	—
*Pigs	120	1300	$1.56x10^8$	$8.8x10^{10}$	$0.48x10^{14}$
*Sheep Goats	745	500	$3.725x10^8$	$1.86x10^{10}$	$0.95x10^{14}$

** Average calorific value of the biogas produced is assumed 5,300 $Kcal/m^3$

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9. The great diversity of biomass energy systems is one of their most attractive features; there is a range of conversion technologies already available yielding a diversity of products, specially liquid fuels to which the world seams to be addicted and on which most world economies have recently been based. Fig.2 shows the biomass as source of energy including processes used to obtain the energy for end user. Biomass conversion, although old, is now rapidly developed method which interests the scientists and engineers, by its practical and immediate output and long-term basic research and development requirement.

Fig. 2 Biomass resources

Biomass Resources	Processes	Products	End user
1-Dry biomass (wood, residues)	Direct burning	Heat, Electricity	Industry, domestic
	Gasification	Graseous fuel Methanol, hydrogen Amonia	Industry, transport Chemicals
	Pyrolysis	Oil, charcoal, gas	Industry, transport
	Hydrolysis and distillation	Ethanol	Transport, chemical
	liquefication	Oil	Transport
2-Wet biomass (Sewage, aquatics)	Anaerobic digestion	Methane	Industry, domestic
3-Sugar (From juices & Cellulose)	Fermentation and distillation	Ethanol	Transport, chemical

The energy assessment should be made in individual countries with or without outside assistance with a view to identifying the energy consumption needs and supply availability of data and potential in this context the priority should be given to a study of the availability of biomass as a source of energy.

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II - Potential and utilization of Biomass including Fuelwood and Charcoal in Africa

10. At national level, urban and rural areas energy demand assessment is very essential to obtain a true picture and patterns of how biomass, including fuelwood and charcoal fit into the total energy or how to integrate the biomass energy in the energy demand pattern (EDP). It is recessary to establish energy need and actual pattern of use the statistics made during the last five years on the energy crisis may not show realiable data. The main sources of energy that could be provided to rural areas in Africa are listed in Fig. 3. This gives qualitative picture of different energy sources for household and agricultural community, one can see from the Fig.3, that the biomass is the major source of energy in this areas. The primary energy sources can be classified broadly as New and Renewable Sources of Energy, including some non renewable ones.

Fig. 3 Main utilized sources of energy in rural areas in Africa

Energy Sources	household			Agriculture		
	cooking	lighting	heating	Power	transport	heat energy
Electricity	*	*		*		
Coke, coal	*					*
Keresene	*	*	*	*		*
Diesel			*	*	*	*
Gas fuel	*	*	*	*	*	*
Biomass	*	*	*	*		*
Solar energy	*		*			
Hydropower				*		
Wind energy				*		
Alcohol				*	*	

11. The existing biomass resources should be carefully assessed and changing conditions such as deforestation, erosion, desertification, population and cash corp pressure, should be taken into consideration. Remote sensing technique, agricultural planning and forestry authorities should all be combined to try to collect and to obtain accurate data on the biomass availability as a sources of energy.

12. The potential for growing biomass as source of energy should be assessed on realistic and sustainable basis with existing species, it should also consider future growth of new plants for biomass generation with more efficient techniques. The factors for conservation of land fertility should be also included, such as nutrient recycling, multi-cultures, etc.

13. The conservation of the soil, nutrient, water, and energy must be of important consideration from the outset of the planning scheme.

14. Also, harnesting and convertion technique with immediate improvement and development of their efficiency should be considered, so that reliable and more effective energy from given amount of biomass and charcoal could be obtained. The system should be carefully analysed to give a true evaluation of suceesses or failures.

15. The evaluation should consider as a basis, the already available and working systems in biomass, fuelwood and charcoal production.

16. The knowledge of availability of soil and of water availability and suitability and climatic and environmental factors are very essential for biomass production as source of energy, considering the competition for land and water.

17. The various end-use paterns of energy which exist at present, or planned for future, must be evaluated as well as the local expertise must be used at its fullest.

18. Every effort should be made to ensure continuity of studies and also to cooperate with groups undertaking similar activities at local, national and regional levels.

A. Biomass technology and its potential

19. The simplest and most direct way of recovering the energy from biomass in the form of heat is the traditional method of combustion. The burning process for biomass can be classified as a thermochemical conversion, which can take place under various conditions and in different types of farnaces: from an open pit which is the least efficient process, to a fluidized bed combustion chamber unit which is the most efficient one. A rapid combustion process has a result on incomplete combustion hence a considerable loss, low efficiency and undesirable environmental problems.

20. On the other hand if the thermal process of the biomass takes place with a limited amount of oxygen it is called Pyrolysis. Pyrolysis should be carried out under limited amount of air and at lower temperature and pressure finding the temperature and pressure of the Pyrolysis process, as well as the moisture content and biomass composition, a variety of products may be obtained such as pyrolytic oil, charcoal (used as solid fuel), and low or medium energy "synthesis gas" containing carbon monoxide and hydrogen. It should be emphasized that the pyrolysis process is related to low-temperature processes which favour the liquid and fuel formation, which gasification is a higher temperature process that generates almost exclusively gaseous fuel. Destructive distillation, thermal craking, carbonization and gasification processes, have been used to describe the pyrolysis processes.

21. In the normal pyrolysis process, heat must be gererated separetely from the reactor with indirect heat-transfer process through walls, by recirculating heat carrying medium or hot flue gas produced from combustion of fuel using storchiometric oxygen-fuel mixture. By comparison, the pyrolysis process of the biomass offer high reaction rate in relatively small plant and the capability of wide variety of feed-stocks into single product or a variety of products, while the fermentation method offers relatively slow converting process of biomass into gaseous and liquid fuels. In the gas fication process of the biomass high temperature is needed resulting in almost exclusively gaseous fuels (synthesis or water gas mainly H_2 and CO).

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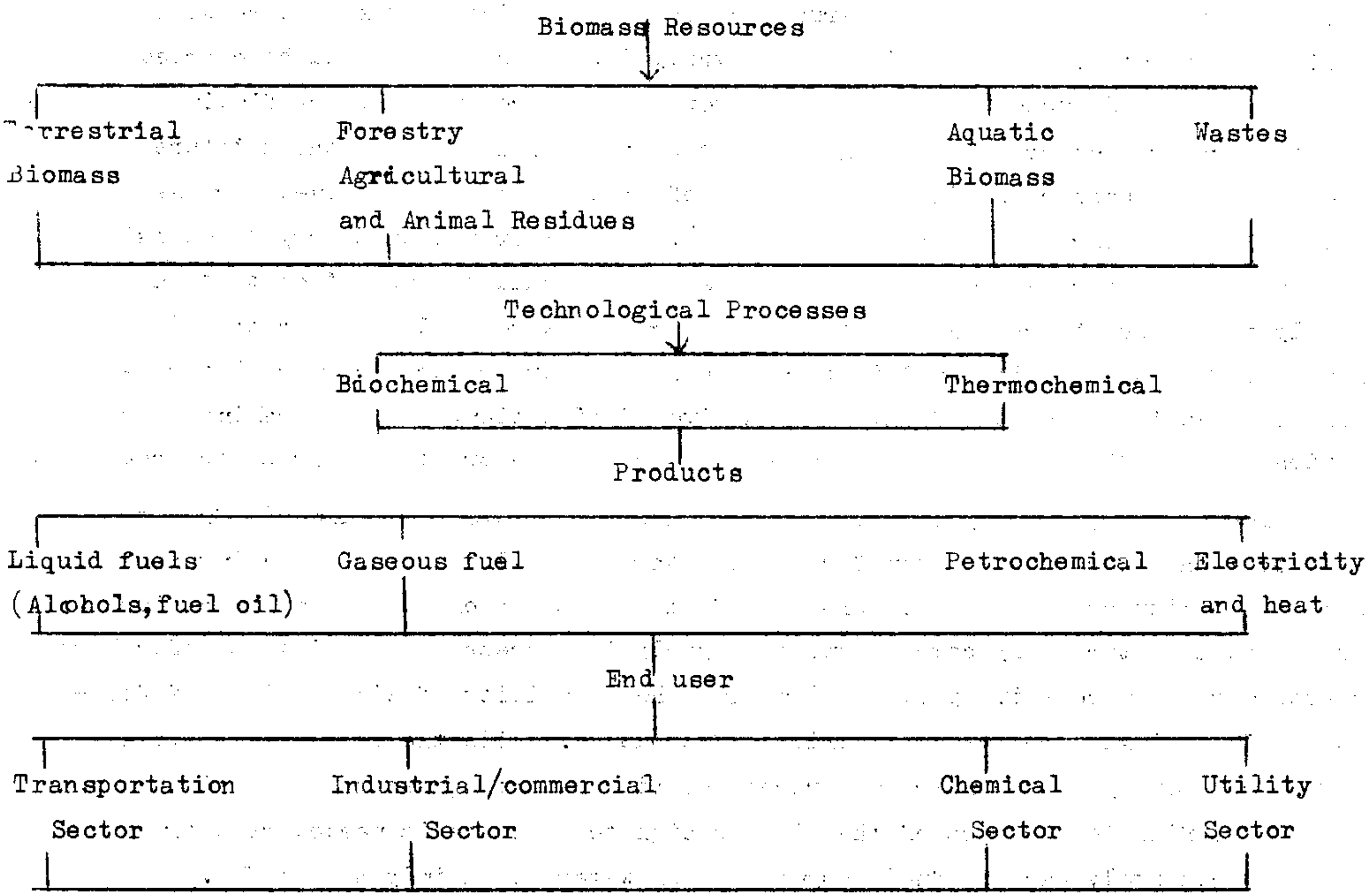
22. The gasification of the wood (as biomass) is a very old process, consequently, the number of types and sizes of gasifiers is very large, but all of than work under the same basic principles, however, the gasification process to obtain low or medium energy gas in presence of limited quantities of air or pure oxygen is the most efficient technology conversion process after combustion. The use of fuel wood and charcoal in steam generation boilers for thermal processes or electricity. Generation is being illustrated in Fig. 4

Fig. 4 <u>Biomass energy systems.</u>



23. The fuelwood is normally milled to reduce it to chips and then fed into the boilers. Overall process efficiencies can approach those of small coal combustion installations. Fuelwood boilers are more expensive than coal boilers and some cost reductions need to be achieved. Although the biomass including fuelwood and charcoal combustions technology is well known and established, technical progress is still desirable and possible, particularly in feeding the fuelwood to the boilers.

24. Labour cost for operating fuelwood boiler is high, because of low reliability of process control. Fuelwood represents a most important source of energy in many developing countries. In India, fuelwood accounts for 32 percent of all energy consumed and for Sudan the figure is about 65 percent. In fact, most of the energy needs of rural areas in these countries are being met by fuelwood, from both forests and farming areas. Fuelwood is also an important source of energy in the industries of these countries such as brick and ceramic manufacture, food processing, rubber production. Fuelwood is also used for cooking and space heating for domestic purposes.

B. <u>Development of utilization programmes of Biomass including fuelwood and charcoal</u>

25. The principal advantages of biomass including fuelwood and charcoal as sources of fuel are that they are socially and environmentally acceptable, they are not particularly hazardous, and can be burnt in large or small and simple equipments which can be locally made.

26. The biomass including fuelwood and charcoal, have low sulpher content and are often locally available. The only byproduct is small amount of ash which has some value of fertilizer as it contains potassium and other minerals except nitrogen which are present in the original wood.

27. Fuel wood can be grown as an energy crop. However, such a programme should not result in indiscriminate conversion of existing forests, into fuelwood for two reasons:

a. Forest products such as lumber and pulp wood have greater economic value than wood used as fuel for direct burning.

b. Wide spread cutting of forests and intense logging can often result in serious environmental problems, unless it is carefully managed.

28. Fuelwood plantation must be given priority consideration in the developing countries to diminish deforestation, flood damages, desertification, irrational use of agricultural and animal wastes, socio-economic problems etc.

29. In fuelwood plantation, the basic problem is what type of plants are the best for energy production, what system sizes are optimal, what conversion process should be applied or what fuel to be produced and what long-range planning and research will be adequate to achieve the desired objectives.

30. The ideal plant for energy production would be one that has a high energy density and requires minimum processing. It should be selected to suit the site environmental conditions, requirements of the processed end-product and be economical.

31. Fuelwood plantation in developing countries and their rapid implementation expansion should be given priority consideration. As stated previously the provision of biomass needs to be maintained on a continuing basis at its present consumption per capita and should be increased. One concept that has not received sufficient attention yet is the possibility of using whole plant communities for biomass production. Such as Mediterranean vegetation which should be harvested on a regular basis instead of being burnt.

32. Animal and crops residues such as cereal straws and bagasse, have a calonific value similar to or somewhat less than wood depending on their ash content, and have advantages and disadvantages when used as fuel by direct combustion. The transportation of these material may pose problems due to their relatively higher bulk, beside the storage problems. They are used as fuel in the rural areas and burnt in a very simple primitive ovens and stoves, a less efficient practice than burning fuelwood.

33. Industrial plants grown in many places of Africa, such as sugar-cane, Nopier grass and sorghum, can yield up to 60 to 90 to dry matter per heater per year. These plants have C4 type photosynthetic metabolism which allows them to make good use of high light intensities and high temperature of the sun whith optimal water use. They are often high in sugar and carbohydrate content and can be fermented to produce alcohols for fuel as is currently done on a large scale in Brazil. The residue of such plants is mostly bagasse and can be used for fuel and animal feeding.

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34. The potential yield of the biomass from fresh water and marine plants such as aquatic plants and algae is very great. However, the extremely high water content of many of these plants when harvested and the difficulty in drying them in the sun may priclude their use as a fuel by direct combustion techniques. Anaerobic fermentation of aquatic plants and wet agricultural wastes appears to be the most appropriate technology for processing of such biomass into fuel and fertilizer.

C. Utilization of Biomass for biogas generation

35. The use of biomass through appropriate technology for biogas generation represents one of the most attractive practices for providing energy in rural areas of Africa. It has the advantage to be decentralized and accessible to village-scale technologies.

36. Biomass residues, vegetative growth and wastes, after significant potential for biogas generation and hence, may contribute to a country's dependance on fossil fuel,

37. Biomass and wastes can be used for producing, electricity, steam liquid fuel, gas fuel and fertilizers. The technology associated with the production of biogas generated from biomass at the village level is in a much greater state of change than is popularly assumed. Many of the technical and economical evaluations that have been carried out so far, have been applied to a limited set of the known techniques. Hence, the aim should be to stress on the examination of wide range of technical and economical alternatives for biogas generation from biomass as a source of energy in rural areas of Africa, and to provide the fertilizers for cultivated lands.

38. The biogas production from biomass is oftenly suggested particularly when animal wastes are used as a main source of house hold energy demand. It has many potential advantages, as follows:

a) Replacement of an inefficient system (traditional) to provide energy by a more efficient and flexible one;

b) Saving the fertilizer valve of the wastes which is lost if the animal dung is burned.

c) Preservation of public health, particularly in the case of eye discases, if the biogas fuel is used as clean and less smokey fuel.

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39. Conversion technology of biomass into biogas has two general methods: Biochemical and Thermochemical. The biochemical conversion of the biomass to generate the biogas consists of two processes:

a) Anaerobic digestions which produces methane gas

b) Fermentation, which produces liquid fuel, mainly ethanol.

40. The anaerobic digestion process is the most common one, because of its wide application in sewage treatment plant to stabilize the settleable solids. The process has its best working conditions in case of organic substances with high moisture content and their conversion takes place in the absence of oxygen to generate methane and carbon dioxide. The quantity of methane is slightly longer than that of carbon-dioxide. The process is very slow at ambient temperature in septic tank and land fills but under slightly, higher temperature than ambient, e.g. 10°C and upto 60°C the reaction speed and methane generation becomes double. The gas produced can be burned directly or can be upgraded into synthetic natural gas by the removal of the carbondioxide. Current research efforts are being concentrated on conversion of other biomass feed stocks such as corn, stover, wheat straw and other energy crops as sugar-cane, sweet sorghum, corn sillage, woody plants and aquatic crops. The results of this research have indicated the need to optimize the yield of energy products and the necessity to speed the reaction process to shorten detention times. Several economical studies have been made on biogas generation from anaerobic digestion process utilizing agricultural residues and aquatic biomass appear to be close to the commercial potential.

41. The fermentation of sugar, molasses or grain can produce liquid fuel (ethanol). Brazil has established a national programme to build alcohol facilities and to produce vehicles adapted to use only alcohol as fuel. Other countries, are using mixtures of gasoline and ethanol in various proportions (up to 20 percent) as transportation fuels.

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42. Thermochemical biomass conversion needs a technology based on elevated temperature to convert the fixed carbon of the biomass material. The known processes are:

a) Direct combustion to produce heat

b) Pyrolysis process to produce gas, pyrolytic liquid, chemicals and char

c) Gasification to produce low or intermediate calorific value gas.

The gas produced can be subjected to indirect liquefication processes to produce amonia and methanol.

43. Direct combustion of biomass provides energy for cooking and heating in the majority of the rural communities in Africa. The biomass for direct combustion may be wood, crop residue and manure. The combustion processes of the woody biomass may take place in open fire or simple cook stoves.

44. The low or intermediate gas fuel produced by gasification or direct liquefication methods, can substitute the natural gas and may be converted into liquid fuel by liquefication processes to produce methanol or gasoline.

Methanol can be used as gasoline extender for industrial and utility gas turbine. Today most of the methanol fuel is produced from natural gas and production from municipal wastes, agricultural residues and other materials is being considered. The cost of producing energy from biomass fuels is determined principally by the cost of the biomass material itself, the conversion system used and the size of the facility utilized.

45. In Africa, like elsewhere, the biomass is used at present as an energy sources, being burned or converted into methane gas through anaerobic digestion. It is known that, the combustion process for generating heat from biomass needs larger quantities of biomass than it would be required to meet the energy needs of the population using biomass. However, in the African rural communities large quantities of agricultural wastes and forest residues and standing biomass are currently used for conversion into heat by direct combustion, although the technology to produce clean gaseous and liquid transportation fuel at a competitive prices with the fossil transportation fuel is also available.

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46. The decision to use biomass as fuel or biomass for generating biogas is a site decision and can be made only by individuals. The governments of Africa should be involved in biomass fuel programmes through studies of the options, techno-economical riabilities and acceptance by rural communities.

III. Prospects of biomass, fuelwood and charcoal production in Africa and their utilization as substitution sources of energy

47. The principal resources of biomass fuelwood ard charcoal are forest, agricultural residues and arimal wastes. In Africa the tropical rain forests and tropical seasonal forests represent the major source for biomass production.

48. A number of good studies have been made and published on the animal productivity in the world, giving the net primary production of the land and ocean areas. Distinction must be made between the rate of carbon fixation and the net production since after the photosynthetic process losses may occur due to physioligical, climatic, pest and disease reasons.

49. The enormous quantity of solar energy stored in the world in biomass is evident. The worlds annual use of energy is only one tenth of the annual photosynthetic solar energy storage. The stored biomass energy on the earth's surface is mostly represented by trees and it is equivalent in quantity to the world's proven fossil fuel reserves. It is estimated that the total stored fossil fuel resources are equal to only about 100 years of net photosynthesis process.

50. The biomass energy resources are available in most areas and their yield is based on a renewable basis without damaging the biosphere. Whereas assessment of the biomass availability on an animal basis is an easy task, it is very difficult to estimate how much energy could be generated from biomass on the same basis. Therefore at African scale, it may be possible to build up only seasonal picture of the overall production of biomass, fuelwood and charcoal. However, at a regional or national level this is going to require much more effort, although it is essential to acquire the data.

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51. In Africa most of the population lives in rural areas, where the main source of energy is fuelwood and charcoal. In some African states, the percentage of non commercial sources of energy mainly fuelwood and charcoal, has varied from 1.5% to 64.9% of the total energy requirement (Fig. 5)

Fig. 5 Energy balance in selected African countries (1000t oil equivalent*)

Countries	Total Energy Requirement	Non-Commercial Energy	%
Algeria	21,563	331	1.5
Egypt	13,900	218	1.6
Kenya	4,404	2810	63.8
Nigeria	23,754	15,426	64.9

* One tonne oil = 4.47×10^{10} Jouls
= 10 million kilocalories

52. More detailed data on fuelwood and charcoal consumption in various African countries is given below:

African State	Biomass energy used	Average/person/year
-Benin (Digernes) (1979)	Fuelwood $9.11 \times 10^6 m^3$/year	2.1-255 m^3/p/y
FAO (1976)	Fuelwood and charcoal	8.2 Gj/p/year 0.6 t/p/y
-Botswana (thipe and and Mokob) 1979	Fuelwood 70% of fuelwood used for heating water	0.75 - 1t/p/y 11-15 Gj/p/y
FAO (1976)	Fuelwood and charcoal	10.6 Gj/p/y 0.7t/p/y
-Gambia (Floor 1979)	Fuelwood 62y of the total energy $2.3 \times 10^5 m^3$ for rural areas (85% of the population) and $4 \times 10^4 m^3$ for urban areas	1.2 m^3/p/y 0.9t/p/y

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Arnold and jongma (1978)	Fuelwood	1.6 m^3/p/y 1.1 t/p/y
FAO (1976)	Fuelwood and charcoal	4.9 Gj/p/y 0.3 t/p/y
-Kenya (1979)	Fuelwood for cooking for 90% of the population	0.7t/p/y
Kabagamba (1976)	Urban charcoal 80% of urban use charcoal	0.1-0.17t/p/y
FAO (1976)	Fuelwood and charcoal	0.6t/p/y
-Nigeria		
McComb and Jackson (1970)	Fuelwood	1.3 m^3/p/y
OJO (1979	91% of energy comes from wood	1t/p/y
FAO (1976)	Fuelwood and charcoal	0.6t/p/y
-Sudan		
Arnold and Jongma (1978)	Fuelwood	1.2t/p/y
	Fuelwood account for 65% of total energy	
	Fuelwood for 99.7% of energy produced in country	
	Biomass produced 28x10^{12} kcal	0.5t wood/p/y
-FAO (1976)	Fuelwood and charcoal	1t/p/y

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-Tanzania		
Openshow (1974)	Fuelwood 99% of population use it. 92% of population in rural used the fuelwood	1.8t/p/y
-Openshow (1976,1979)	Fuelwood	1.5t/p/y
-Arnold & Jongma (1978)	Fuelwood	1.7t/p/y
-Makijiani & Poole (1975)	Fuelwood	1.5t/p/y
-Brown & Howe (1978)	Biogas	single family
-FAO (1976)	Fuelwood and charcoal	1.7t/p/y
-Tunisia		
Hamza (1978)	Fuelwood use	0.2t/p/y
Rural areas	Fuelwood use	1.2t/p/y
Urban areas	Fuelwood use	0.1t/p/y
FAO (1976)	Fuelwood and charcoal use	0.2t/p/y

A. Impact on the environmental, economical and social aspects

53. The use of biomass, fuelwood and charcoal as basic fuel sources may arise problems related to the environmental, social and economical programmes of development in certain countries. New technologies cannot successfully be introduced without introducing, and involving the local population. Attempt should therefore be made at earliest stages to obtain the involvement of the local population and national leaders, in the introduction of their schemes, taken into consideration that the successful introduction depends on their adaptation to the local cultural and social conditions. The technologies of biomass utilization in a most efficient way to meet the needs and habits of the local population should be carefully studied in relation to the technical capability of the local population and their educational system. Appropriate training programmes and popularization programmes to cover all the needs in this field should be elaborated at an early stage.

54. It should also be taken into account the impact on health and air pollution as well as the environmental changes such as overstreas of the capacity of soil and its quality.

55. The assessment of the impact of the use of biomass on the economic situation in a country or limited area is not sufficiently studied. Very few economic analysis have been done recently and some of them relies on cost effectiveness criteria. However in areas where the conventional sources of energy are absent, it is probably for better to use the cost benefit analyses to compare different means of providing new and renewable sources of energy. It is very important to have such studies and investigations for any consideration of biomass energy systems. It is not an easy matter, the economic analyses are usually even more difficult to be done properly than any other type of analyses. It should be recognised that the small scale industries and urban populations can be more for biomass materials resources than rural population.

56. For the social and institutional problems, it is very important to early assess these problems which may arise with the implementation of any new or renewable sources of energy (such as biomass) programme, whether the implementation is based on new or existing used patterns. The early involvement of the local population and their leaders is essential in order to face the realities of the existing situation.

B. <u>Training and Education related to biomass technologies</u>

57. The lack of trained personnel can often be the important limiting factor to the implementation of any biomass energy scheme. This fact should be recognised and attempts should be made as soon as possible to alter this limitation.

58. Training courses should be held on regular basis in each of the African states or on a regional basis. Such courses may be based on soft and hard work for both students and lecturers. The courses should be started on widespread basis as soon as possible, utilizing the experiences and lecturers from both developed and developing countries.

59. In general, training and education in the field of utilization of biomass and its derivatives should be made in cooperation with agricultural schools, universities, high institutions and research centres.

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IV - Suggestions and Conclusions

60. Some African countries, have experience in biomass and biogas generation, fuelwood and charcoal production. This experience should be carefully studied and investigated to be used for direct implementation in other countries. The time scale for such implementation and utilization should be clearly defined so to not raise too high expectations for immediate results. Often, the use of biomass for energy systems takes considerable time before it has any significant impact on the energy status of a community no matter how big or small.

61. The successes or failures of previous biomass energy systems should be carefully analysed in order to establish what factors may encourage or preclude the introduction of such systems in any one region or country.

62. Some data are already existing and it would be worthwhile to be assembled a manual instruction book on the biomass, technology and utilization as soon as possible . The manual may also cover the aspects of using the local material, considering the training programmes and the local labour skillness.

63. Related to such a manual book, demonstration schemes and models should be made to show the advantages and opportunities and to involve the local population in their construction and utilization.

64. Each of such demonstration scheme should be carefully studied and the information gained should be exchanged with other member States. The information should describe the successes as well as the failures and may provide data related to the implementation programmes, such as the impact on the environmental changes, social and economical features of the population within the demonstration area.

65. The United Nations specialized agencies may share and play a significant role in the information exchanges in technical assistance programmes by supporting technical missions from one country to another for the purpose of transfering the experience of biomass technology and utilization.

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66. This programme may create a basis to regional and international cooperation.

67. Organization of study tours for African experts in the field of biomass conversion to countries having sound experience in the field of biomass technology and utilization.

68. Accelerating of biomass utilization in urban and semi urban areas will react on the fuel oil importation for many African states and hence will support the development programme.

69. A supporting implamentation programme from UN agencies in African member States to encourage them to transfer some of their local industries to change their firing system from fuel oil to biomass system including fuelwood and charcoal.

70. An environmental programme should be carefully established sound and sustainable way for conservation to provide new and renewable sources of energy in particular fuelwood and biomass.

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