OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

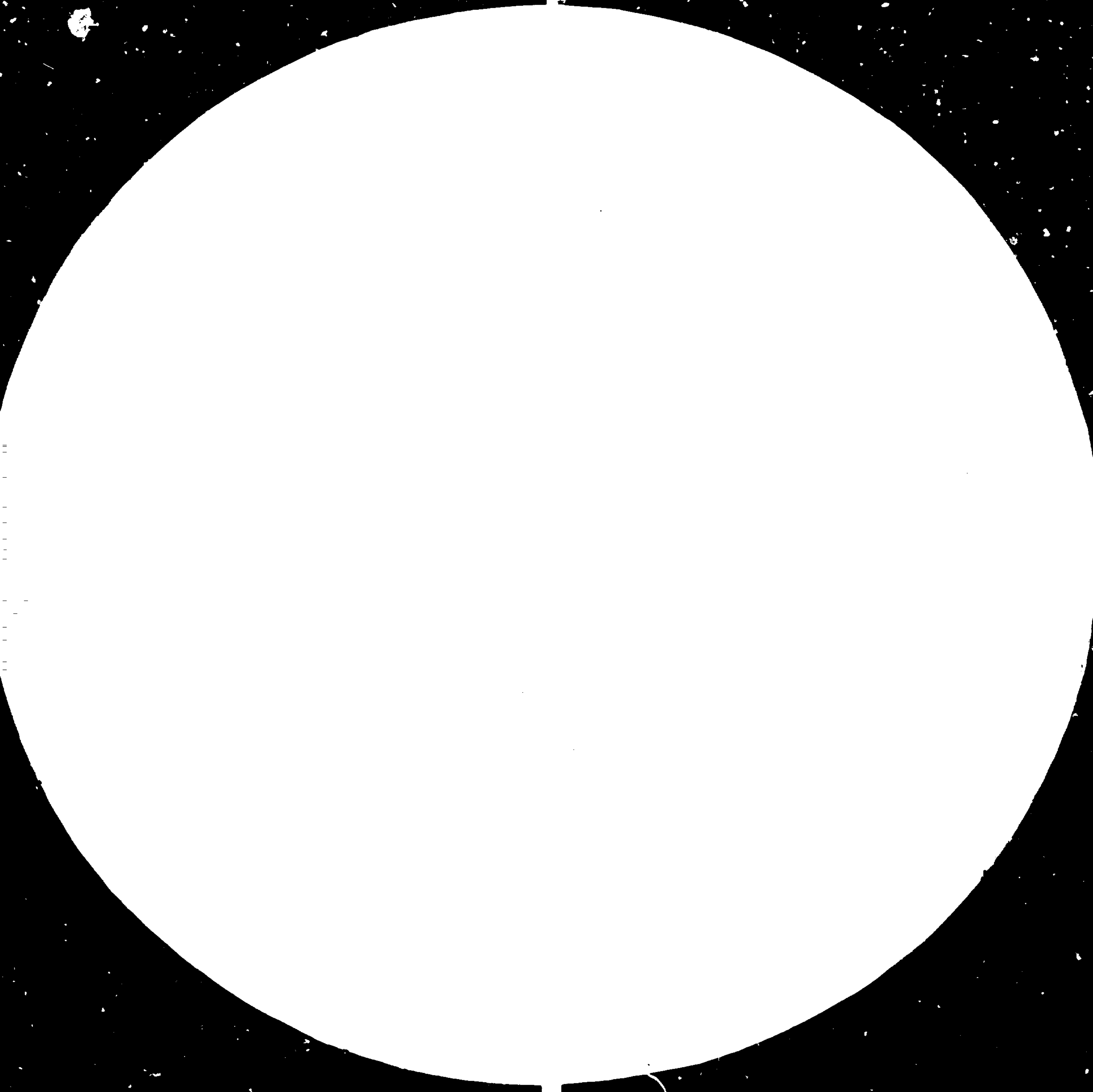
FAIR USE POLICY

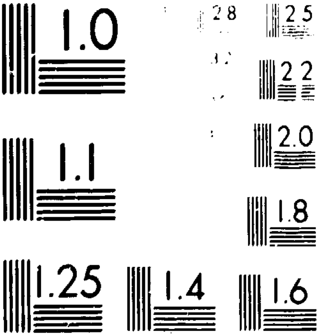
CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org




1.0
2.8
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

12100

United Nations Industrial Development Organization

Distr.
LIMITED

ID/WG.384/6/Rev.1
7 March 1983

ENGLISH

Expert Meeting Preparatory to International Forum *on Technological Advances and Development*

Moscow, USSR, 29 November - 3 December 1982

IMPLICATIONS OF BIOMASS ENERGY TECHNOLOGY FOR DEVELOPING COUNTRIES*

prepared by

UNIDO Secretariat

157

* This document has been reproduced without formal editing.

V.83-53160

Contents

INTRODUCTION

1. This paper presents a preliminary assessment of the major issues involved in biomass energy technology in developing countries. It does not attempt to provide the answers to the many technical and policy problems, nor is it intended to be a systematic or exhaustive analysis of the subject. The aim is to provide a perspective and focus for the discussion of such a wide ranging and multidisciplinary subject as biomass technology.

2. Biomass is all plant and animal material which can be used as a source of energy. This includes wood, grass and legume herbage, cereals and sugar crops, crop residues, animal manure, food processing wastes, oil bearing plants, freshwater and saltwater aquatic plants. From such a list it is not surprising that the quantities of biomass available are very large, and renewable. The biomass productivity potential of the forests of the world has an energy content of nearly three times the world's current energy use. [1/]

3. Estimates have been made of the share biomass provides of the world's total energy needs. One such estimate shows that biomass provides between 6 and 13 per cent of total energy needs worldwide. [2/] But such estimates, as the authors themselves admit, can only be best guesses because much of the biomass used for energy production is not recorded in any commercial energy statistics. What is clear however, is that biomass provides the major source of energy in developing countries, especially in the rural areas. Fuelwood is the most important form of biomass as can be seen from table I.

1/ Report of Technical Panel on Biomass Energy, A/Conf.100/PC/28 UN Conference on New and Renewable Sources of Energy (Nairobi, 1981).

2/ World Bank, Energy in the Developing Countries, (Washington D.C. 1980).

Table I

Share of fuelwood in total energy consumption:

Region / Country	Percentage
Africa	60
Asia	20
India (national average)	56
India (rural areas)	93
Latin America	20
Western Europe	0.7
World	10

Source: Synthesis of Technical Panel Reports, A/Conf.100/PC/42 United Nations Conference on New and Renewable Sources of Energy (Nairobi, 1981).

4. Biomass in its many different forms has many competing uses. Fuelwood competes with wood for construction purposes, pulp and paper etc. Grasses are used for animal feed and grains, sugars etc. for human consumption, clearly illustrating the problem of biomass energy competing with food production. Unfortunately in the majority of developing countries, especially the least developed, the shortage of energy goes hand in hand with food shortages. It is therefore essential that the energy, food and raw material potential of biomass is balanced in an integrated systems approach in line with the particular needs and resources of countries.

I. CURRENT BIOMASS ENERGY PRODUCTION AND CONVERSION TECHNOLOGIES

5. Technological advances in biomass cover a wide spectrum from the new, the product of the latest research, to the upgrading of traditional systems which have been in use for many years.

6. There are developments taking place in all the technologies associated with biomass production and conversion but it is in the field of genetic engineering and biotechnology that some of the most significant technical advances are occurring. One of the most important is the work on genetic engineering for the efficient conversion of cellulose and hemi-cellulose to ethanol by using genetically manipulated microorganisms and by using recombinant DNA technology especially for molecular cloning and amplification of cellulose genes. [3/]

7. It is essential to consider biomass production methods as well as the conversion systems because they jointly determine the quantity of useful energy obtainable.

8. In most developing countries there has been little attention paid to the type or method of growing biomass. Usually the biomass resource

---

3/ For more detailed discussion see "Application of Genetic Engineering for Energy and Fertiliser Production from Biomass" by G. Ray Wu, ID/WG.382/2 Add.2 (September, 1982).

is the naturally occurring vegetation, or the wastes from crops grown for food.

9. Some attempts have been made to produce specific crops for energy purposes - energy farming. On the whole these have been research projects in developed countries rather than practical efforts in developing countries.

10. Research has shown that for maximising biomass output from forestry trees are grown closer together and for shorter periods than the normal forestry practise. Similar research work is going on regarding other crops such as sugar-cane, sweet sorghum, cassava, soy bean, sunflower and napier grass. The aim is to select high energy yielding plants with as low production and processing costs as possible. Aquatic plants, both freshwater and saltwater species, are also being considered as an energy source. The advantage of aquatic biomass is that it does not take up land which has many competing uses.

11. Another method of increasing the biomass resource base is the better collection and utilisation of crop, animal and solid municipal wastes. This is most efficiently carried out if the whole system is integrated. For instance by combining "whole-tree usage" with improved forest management practises, productivity per unit area can greatly increase the resource base for both traditional forest use and for energy purposes. 4/

12. Biomass is converted into energy by many different processes from the very simple such as burning, to the very complex. It is also converted into a number of different energy forms. In general, biomass conversion technologies can be divided into two broad categories, thermochemical and biological.

A. Thermochemical Conversion

13. Direct combustion of biomass is one of the oldest forms of energy production

---

4/ Sten Söderman, "Short Rotation Forestry in Sweden: A Case Study for Technical Panel on Biomass Energy" United Nations (Geneva, 1980) and the one that is most commonly used in the developing countries. At its simplest level it is an open fire which provides energy for cooking and heating with a thermal efficiency as low as 5 per cent. Improved stoves have been designed which are up to 80 per cent efficient, but they are not widely available in developing countries.

14. Pyrolysis of biomass (thermal decomposition in the absence of oxygen) can provide liquid fuel (oils),low calorific value gas and charcoal. These fuels either directly or after further processing can be used for a wide variety of domestic and industrial applications.

15. Gasification of biomass involves the thermal decomposition of organic matter with an auxiliary gas such as air or oxygen. Low calorific value gas is produced which can be used for gas engines, power generation and industrial uses. Research is under way to improve the thermal value of the gas produced and to convert the gas to a liquid fuel, either methanol or a synthetic fuel (gasoline). The problem is generally not the technology but the reduction in the cost of the process to make it competitive with conventional fuels.

16. The major factors to be considered in the selection of a process for biomass gasification are: that the raw gas produced should be of appropriate composition and pressure - little or no undesirable components; the process should have a high gasification capacity and high carbon conversion efficiency and be energy efficient; the plant should be able to handle a variety of biomass feedstocks of different sizes and moisture content.

17. Thermochemical gasification processes are classified according to the type of bed used and the type of reactor vessel. There are three basic types of commercial reactor: fixed bed, fluidised bed and entrained bed.

18. Advanced gasification processes designed specifically for biomass are in various stages of development. These advanced processes emphasize

catalytic gasification or steam gasification as opposed to the early air blown processes. The catalyst is used to increase the reactivity of the feedstock which is important because biomass has a lower energy content relative to coal.

19. Direct liquefaction of biomass with high temperatures and pressures with catalysts is a technology which is being developed in several countries.

B. Biological Conversion

20. Biomethanation (anaerobic digestion) is a microbiological process which converts biomass into a fuel gas composed of methane and carbon dioxide (biogas). There are a number of digester designs depending on the biomass feedstock and local materials and conditions. The gas produced can either be used directly or it can be upgraded by the removal of carbon dioxide.

21. The following is an example of the biomethanation process using animal waste as the feedstock. 5/ The process is:

$$\text{Animal waste} + \text{water} \xrightarrow[\text{bacteria}]{\text{anaerobic}} \underset{\text{methane}}{3\ N\ CH_4} + \underset{\text{carbon dioxide}}{3\ N\ CO_2}$$

The animal manure, containing 85 per cent water is pumped from a holding tank through a mill to the digesters. The slurry is preheated by passing through a heat exchanger against the effluent from the digesters. If further heating is needed direct steam is introduced. The digesters are left at 55° C by steam injection to promote growth of thermophillic anaerobic bacterial flora, introduced originally with the manure. Air is excluded from the digesters. Agitation at about 9 RPM promotes uniform action in the vessel. Gas leaving the digesters consists of about 60 per cent methane and 40 per cent carbon dioxide with traces

5/ Taken from Biomass Process Handbook (Technical Insight Inc. November 1980).

of hydrogen sulphide. It is compressed for pipeline transportation as a fuel or chemical raw material. Part of the gas is used as a boiler fuel to provide the steam needed in the process. The liquid effluent from the digesters, after giving up part of its heat to the incoming feed is treated with flocculants, settled and dewatered by filtration to obtain an animal feed material.

22. A more futuristic approach is the use of algae as the feedstock for biogas. 6/ The algae would be cultured in shallow ponds on non arable dry coastal areas. The pond would be fed by seawater. In the ponds filamentous, mixtorphic algae are grown and harvested off by filtration. To protect the algae from zooplankton, biological filters such as mussels, shrimps etc. are placed into the incoming seawater. The algae biomass is converted into biogas by anaerobic fermentation. The CO_2 is stripped off and with the residual sludge is fed back to the ponds to encourage growth.

23. The success of any such venture would depend critically on the yield of algae. Therefore developing countries with hot sunny climates ideally suited to algae growth would have a relative advantage.

24. Ethanol fermentation converts sugars (from carbohydrates and starches) using microorganisms, into ethanol. A number of developed and developing countries have facilities for ethanol production from biomass. These vary in design and size with the largest at 700,000 litres per day. The ethanol (gasohol) produced can be used directly as a motor fuel as in the case of Brazil or it can be used as a gasoline extender with a 10 - 20 per cent ethanol to 80 - 90 per cent gasoline mixture. The major limitation on the widespread use of ethanol fermentation especially in developing countries is that the normal feedstocks are also valuable food commodities.

6/ Energy from Biomass and Wastes, Symposium Papers of the Institute of Gas Technology meeting at Washington, D.C. (August 1978), Institute of Gas Technology Chicago, Illinois.

25. Ethanol from molasses is a basic process for producing ethanol by fermentation of all types of sugar combining materials. 7/ The process is:

$$C_6H_{12}O_6 \xrightarrow[\text{enzyme}]{\text{Yeast}} C_2H_5OH + CO_2$$

glucose ethanol carbon dioxide

Yeast (saccharomyces cerevisiae) is grown in a series of large aerated fermentors in a medium of molasses, an ammonium salt and water. Yeast from the final culture tank is added to molasses and water in large non-aerated production fermentors. Acid is added to bring the PH value of the liquid to about 4.5. Heat exchangers are used to keep the temperature to 30^{o} C. Fermentation is complete in about 40 hours. Then the mixture (beer) containing 6 to 10 per cent ethanol is filtered to remove yeast cells and then passed to the distillation column. The spent yeast cells and the bottoms from the distillation column are processed into animal feed.

26. Lignocellulosic fermentation is the conversion of agricultural and forest residues into sugars by acid or enzymes and then into ethanol. The advantage of this technology, which is still at the research stage, is that it provides a much wider feedstock for ethanol production and it utilises crop and forestry wastes rather than sugar and grains which could be used for food.

27. The advances in the technology for breaking down lignocellulosic material to useful chemicals are really concerned with finding the right microorganisms to achieve the depolymerization of the material. It is reported 8/ that scientists at the National Research Council of Canada have managed to convert cellulose to methane in a mixed culture of only three microorganisms.

7/ Taken from Biomass Process Handbook, (Technical Insights Inc. November 1980).

8/ "The Potential Impact of Microbiology on Developing Countries" by Carl-Göran Hedén (UNIDO/IS.261, 1981).

28. One of the major problems has been to separate out the cellulose material which is relatively easy to convert to ethanol, from the lignin which does not convert through biological means. A new and promising technique is the fractionation of the biomass such as the hydrothermal explosion of wood chips. From this it is possible to separate out cellulose fibres which can be converted to glucose by enzymes and then to ethanol from the alcohol soluble part containing most of the lignin. The lignin is in the form of a thermoplastic polymer which has potential as a chemical feedstock. It would also be used as an energy supplement because lignin has more fuel value per weight than ethanol. [9/]

29. As there are advances taking place at different rates in all branches of biomass energy technology it is convenient to summarise the most important lines of development impacts, potential and problems in a tabular form.

9/ Advances in Biochemical Engineering Edited by A. Feicher, Springer-Verlag 1981

BIOMASS RESOURCE BASE

Route and state-of-the-art	Impacts	Potential	Problems
1. Large-scale forestry biomass production and collection in terms of land and area and wood output levels. Technology available.	Will influence land-planning. Mechanization will have to be imported and adapted.	Could expand the raw materials for fuels and industrial purposes substantially. Will provide work opportunities in the countryside.	Calls for training of personnel from medium to highly skilled levels. Service back-up needed for mechanical components. Capital investment.
2. Improved utilization of forest residues, agricultural, industrial and municipal residues. More or less commercial technology.	Can be implemented. Low-cost, no major research needed. Influence on planning and infrastructure.	Will provide new raw materials for fuel-production (biogas, producer gas, firewood and charcoal).	No specific technical problems. Need training of personnel in developing countries.
3. Aquatic-biomass production. Technology at R+D level.	Will have impact on food/feed/energy balance.	Important potential but still at R+D stage. Fermentation of e.g. sugar and water hyacinths seems promising.	Technology is not yet developed and proven. Cost-intensive.
4. Application of biotechnology, e.g. improvements in plant species for energy use. Technology at R+D level	Will have substantial impact on productivity. Links with biotechnology.	Will accept less productive land areas. Strengthen competitiveness to other land uses.	Highly-skilled scientific capacity needed.

BIOMASS CONVERSION TECHNOLOGIES

Route and state-of-the-art	Impacts	Potential	Problems
Thermochemical conversion			
1. Direct combustion. Advances in cooking technology (open fires and primitive stoves). New scientific advances based on low-technology i.e. improved stoves and charcoal kilns, based on local materials and skilled manpower.	Immediately available and very wide potential. (250 million people face fuelwood shortage now and 1 billion in the near future)	Several-fold increase in efficiency (5-40%). Forestry resource base can be manufactured mostly with local materials and labour.	Needs information, education in manufacture and utilization.
2. Pyrolysis. Not generally available on a commercial scale; at R+D stage in some countries. A more efficient way of utilizing wood than charcoal products but investment costs are higher.	Wide potential in developing countries and especially for small-scale industrial applications because of gas and tar production; low to medium technology which eventually could be manufactured locally.	May cover small-scale local demand for gas and liquid fuel and industrial purposes.	The technology is not readily available. Capital investment and skilled manpower.
3. Gasification. Low efficiency technology is available but advanced technologies at R+D stage. Requires sophisticated process technology.	Prospects for countries with large deposits of peat, lignite, forestry and agricultural residues. Only covers local and short distance needs.	Provides clean fuel for households and industrial consumers. Can replace imported liquid fuel, little environmental effect.	Very capital-intensive. Equipment would have to be imported. High level of skills needed. Designed for single feedstock such as peat.

Route and state-of-the-art	Impacts	Potential	Problems
4. Direct liquefaction. Laboratory-scale research in developed countries.	If possible and cost-competitive, would provide liquid fuels.	Can substitute for motor fuels.	Not proven technology. Catalyst and high cost R+D needed. High energy cost.
	BIOLOGICAL CONVERSION		
1. Biological Biomethanation (biogas). Wide-scale application of low-level technology of batch type. Advanced continuous processes have been developed.	Very high, especially for tropical zones with agricultural residues, municipal sewage and aquatic biomass.	Improved sanitation, produces fertilizer of high quality and biogas energy source. Suitable for mass production in developing countries.	Advanced research, education and training needed. Under primitive conditions and variable feed, process is very slow and needs a new bacteria to speed up process. Therefore, stable feed content of homogenous type is needed for rapid process.
2. Ethanol fermentation Commercial plants are available at small to medium scale.	Suitable only for countries with surplus grains and sugar. Competes with food production. Therefore relevant to very few developing countries.	It provides a high quality motor fuel or additive. Residuals can be used as animal feed.	Food-energy competition. High investment cost. Sophisticated process requires highly skilled personnel. Could give rise to problems of alcoholism.

Route and state-of-the-art	Impacts	Potential	Problems
B. Lignocellulosic fermentation.			
(a) Acid. Commercially available. Generally linked with large-scale pulp and paper production and	Specially suitable for countries with a forestry industry. High potential.	As with ethanol fermentation, may cause environmental pollution. Production of lignin which can be used as a fuel or chemical feedstock.	High investment cost. Medium to large-scale. Limited to industrial plants. Corrosion problems in processing vessels.
(b) Enzymes. At laboratory research stage. Potentially very efficient in terms of energy efficiency and use of raw materials.	Opens up new ways to produce ethanol from forest wood, preferably in conjunction with forestry industry.	Will expand the possibilities to produce ethanol from forest wood.	Highly skilled R+D is required. Cost-intensive. Needs advanced way to decompose the wood into cellulose and lignin prior to enzyme treatment. Low capacity of the enzymatic reactions.

New technologies for separating the ethanol from the water-ethanol mixture produced in (a) and (b), such as membranes and adsorbents technologies, are at the R+D stage. These technologies are very promising alternatives to fuel-consuming distillation processes.

II. POLICY IMPLICATIONS FOR DEVELOPING COUNTRIES

30. As seen earlier biomass is a major energy contributor in virtually all developing countries. For this reason alone it is imperative for developing countries to examine the future direction of biomass technology. In many developing countries fuelwood is becoming a scarce commodity and it has been estimated that some 250 million people in developing countries face acute shortage of fuelwood and another 1,000 million are in a deficit situation. 10/ Therefore improvements in the harvesting and utilization of fuelwood and the introduction of alternative energy supplies will be needed in the coming decade.

31. Biomass resources and conversion technologies cover a very wide field from the very simple and low cost to the very complex and large scale. The major research work being undertaken can be classified as seeking ways of upgrading technology rather than identifying completely new systems. In addition, methods are being developed to increase the biomass resource base through energy cropping or better management of agricultural wastes. It is clear that the economic viability of biomass energy is much improved if an integrated and systematic approach is applied from the very beginning of the operation. This would mean linking the forestry and agricultural sectors needs and outfits with the industrial and domestic energy needs of the region. This may require the examination of some very basic institutional factors such as land and industrial ownership, size of farm, etc.

32. Not only can biomass energy be supplied from a of feedstocks and processes but it is or can be produced in a wide variety of forms to meet a wide number of uses. It is therefore possible, with planning, to provide the right form of energy or fuel for the various sectors of the local or national economy.

33. Because of the wide range of biomass feedstocks and the plurality of conversion technologies, it is necessary to carefully match biomass energy production in its various forms with the different sectors of use.

10/ Preparatory Committee for the United Nations Conference on New and Renewable Sources of Energy. Synthesis of Technical Panel Reports. A/Conf.100/PC/42, 4 March 1981

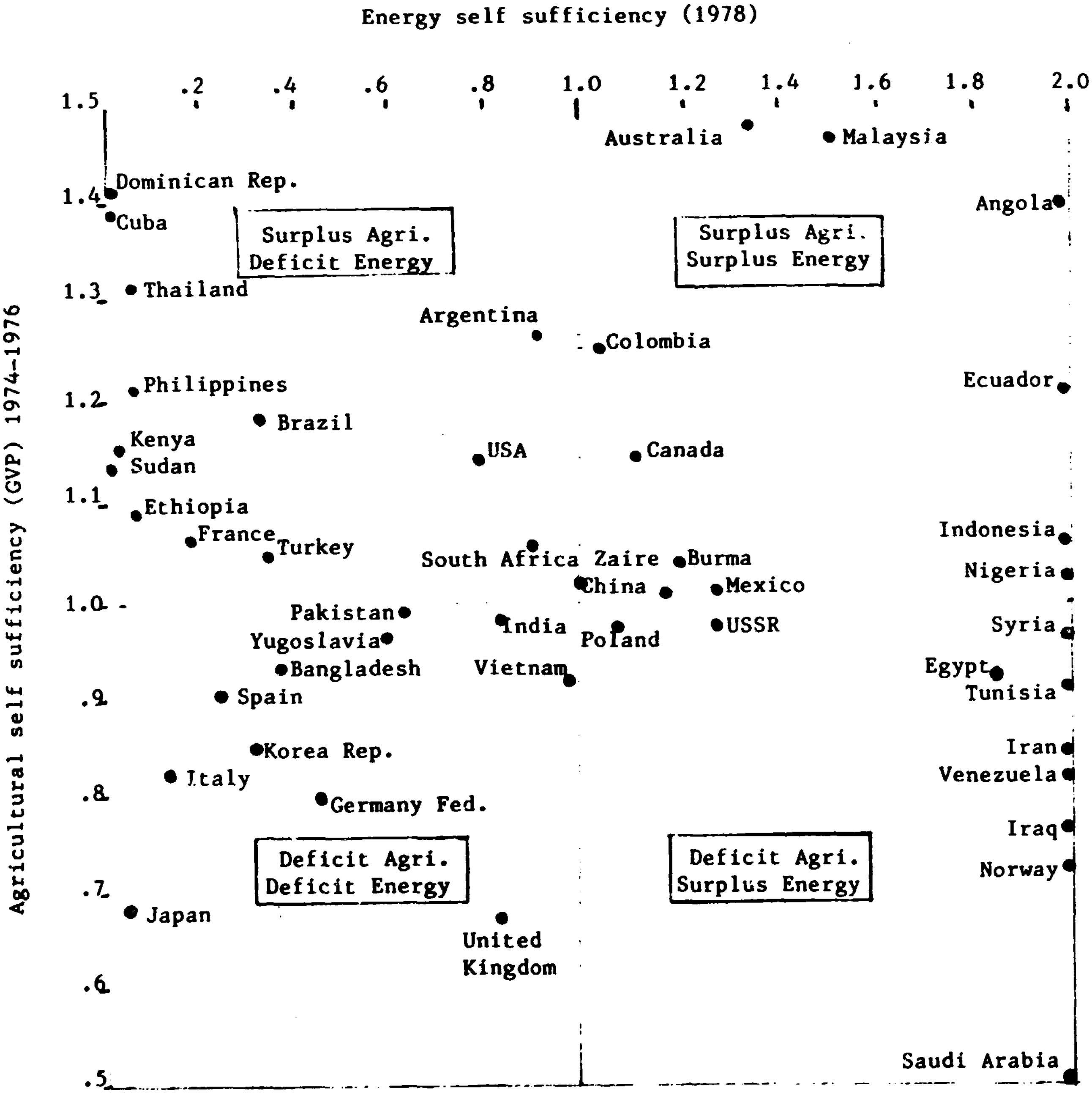
This is a complex task and can only be tackled after detailed socio-economic and technical research for the particular region concerned.

34. The exact share biomass energy should or could provide for a developing country energy needs will be determined largely by the other sources of energy that are available, their price and security of supply. For countries without hydrocarbon resources, the gaseous and liquid fuels that can be obtained from biomass will be very attractive.

35. At the present time ethanol from biomass is produced commercially from grains and sugars. These feedstock have two distinct disadvantages. Firstly they are agricultural products with competing demands as food and animal feedstocks. In the case of Brazil and the United States of America there may well be surplus of sugar and grain respectively, but this is not true for countries generally, especially the developing countries where there is usually food shortage. Secondly, the net energy balance for the production of ethanol from sugars and grains is a matter of considerable debate. Some evidence from the United States shows that, when account is taken of the fertilizer and process requirements for ethanol from grains, the net energy balance is negative. Therefore, whether countries are in a position to embark on ethanol production from grains and sugars will depend on their energy and agricultural production, and a calculation of the net energy balance. Figure I below shows the energy/ agricultural self-sufficiency position for a number of countries.

36. If ethanol can be produced from lignocellulose material this would have several important benefits. The most important is that it would avoid fuel versus food problem surrounding sugar and grains. Lignocellulose material is probably the largest source of biomass and therefore the amount of ethanol that could be produced would really provide an alternative to petroleum. Most lignocellulose material has much lower input of energy in the form of fertilizers etc. than agricultural crops and therefore the energy balance would (given an energy efficient conversion system) be positive.

Fig. I Energy and agricultural self sufficiency



Source: RASK. N. Biomass is utilization as food and/or fuel
IV International Symposium on Alcohol Fuels
Technology, Guaruja, SP. 5-8 October 1980
Vol. III pp 953-964 Proceedings

37. The production of biogas from municipal and animal waste is now being carried out in many developing countries. It is reported that over 7 million digesters have been built in the Peoples Republic of China since 1970 and that India has subsidised the installation of 70,000 small biogas plants. 11/

38. These plants do not only give energy to small rural communities but also improve public hygiene and provide a valuable fertiliser from the residue of the biogas plant. There is however a need to improve the efficiency of biogas production and at the same time reduce its cost. The comment has been made that unless improvements can be made, biogas fermentation will always be at best a marginal contributor to rural and industrial development. 12/

39. A very important aspect of both methanol and ethanol from biomass for the developing countries is that apart from the energy potential, it also provides an indigenous route to petrochemicals without the need for sources of petroleum. This is not to say that petrochemicals from non-petroleum sources will take a major share worldwide but it could be very significant for developing countries which at the moment have to import petroleum for both energy and petrochemicals.

40. The equipment required for most biomass conversion technologies is not very complex. The result is that it is possible for much of the equipment needed to be fabricated locally in developing countries. The problem is that the designs and processes are usually the property of companies in developed countries. It is therefore essential that the developing countries with biomass energy potential - and that includes the vast majority - develop a local design and construction capability for the various biomass technologies.

41. Although currently much of the "know-how" on biomass technology is in the hands of the private sector in the developed countries, the developing countries have a bargaining counter in that the prime market for the use of that technology is the developing countries. For instance it might be

11/ E.A. Van Baren "Biogas Beyond China: First International Training Programme for Developing Countries". Ambio 9.10.1980

12/ A. Barnett, L. Pyle and S.K. Subramanian "Biogas Technology in the Third World: A Multidisciplinary Review". International Development Research Centre, Ottawa, Canada, 1978.

possible for a number of developing countries to jointly negotiate with the companies owning the technology thereby obtaining improved terms and conditions.

III. OPTIONS FOR INTERNATIONAL ACTION

42. As can be seen from the above discussions developing countries have a number of opportunities open to them in relation to the development and use of biomass for energy. For full advantage to be gained from those opportunities it is essential that developing countries acquire the latest information and knowledge on omass energy. This has to cover all aspects of the subject from improved biomass resource management through new conversion technology to more efficient end-use. At the same time the developing countries need to develop and strengthen their consulting, design and construction capabilities in the subject.

43. Due to the multidisciplinary nature of biomass energy, it is essential that the ongoing and future developments of each of the component disciplines is taken into account in the formulation of policy at the national, regional or international level.

44. Research and development relating to biomass energy is being carried out in one form or another in many countries. In this connection UNIDO is compiling a directory of research and development institutions working on the industrial conversion of biomass. This shows that there are 154 research institutes in 47 countries of which 60 are located in 31 developing countries. These figures must be regarded as conservative because they only include those institutions which have been identified and who have responded to a questionnaire.

45. The scale and intensity of biomass R&D in developing countries can also be gauged from the UNIDO study referred to above, which shows that 539 professional staff were engaged in biomass research in the 60 institutions. The 1981 budget for R&D on industrial conversion of biomass in these institutions in developing countries was approximately $12 million. This again has to be regarded as a conservative figure

because a number of the institutions did not provide budget information and others may not have included the salaries and overheads of the professional research staff.

46. The type of R&D being carried out on biomass energy covers a very wide spectrum including basic research, laboratory scale, pilot plant and industrial application. Obviously there will be overlap and duplication in the R&D being carried out in developing countries, but this has in many cases to be regarded as necessary for indigenous capacity building.

47. However, whenever possible, R&D activities should be co-ordinated among developing countries to maximise the benefits from the scarce resources employed. For the same reason, the results of the R&D should be given wide dissemination among developing countries.

48. There are a number of possibilities for international action and co-operation concerning biomass energy technology. For example:

1. An international mechanism of a comprehensive nature covering all aspects of the subject.

2. Centres of excellence related to one or more biomass energy technologies, on a regional basis or in selected developing countries.

3. A network of research institutes working on biomass energy.

4. Monitoring and information system for advances in the various technologies concerned.

49. The various options for action need careful consideration and it is to be noted that the above list is not exhaustive. In addition it is not necessary to consider only one option because those given are not totally exclusive.