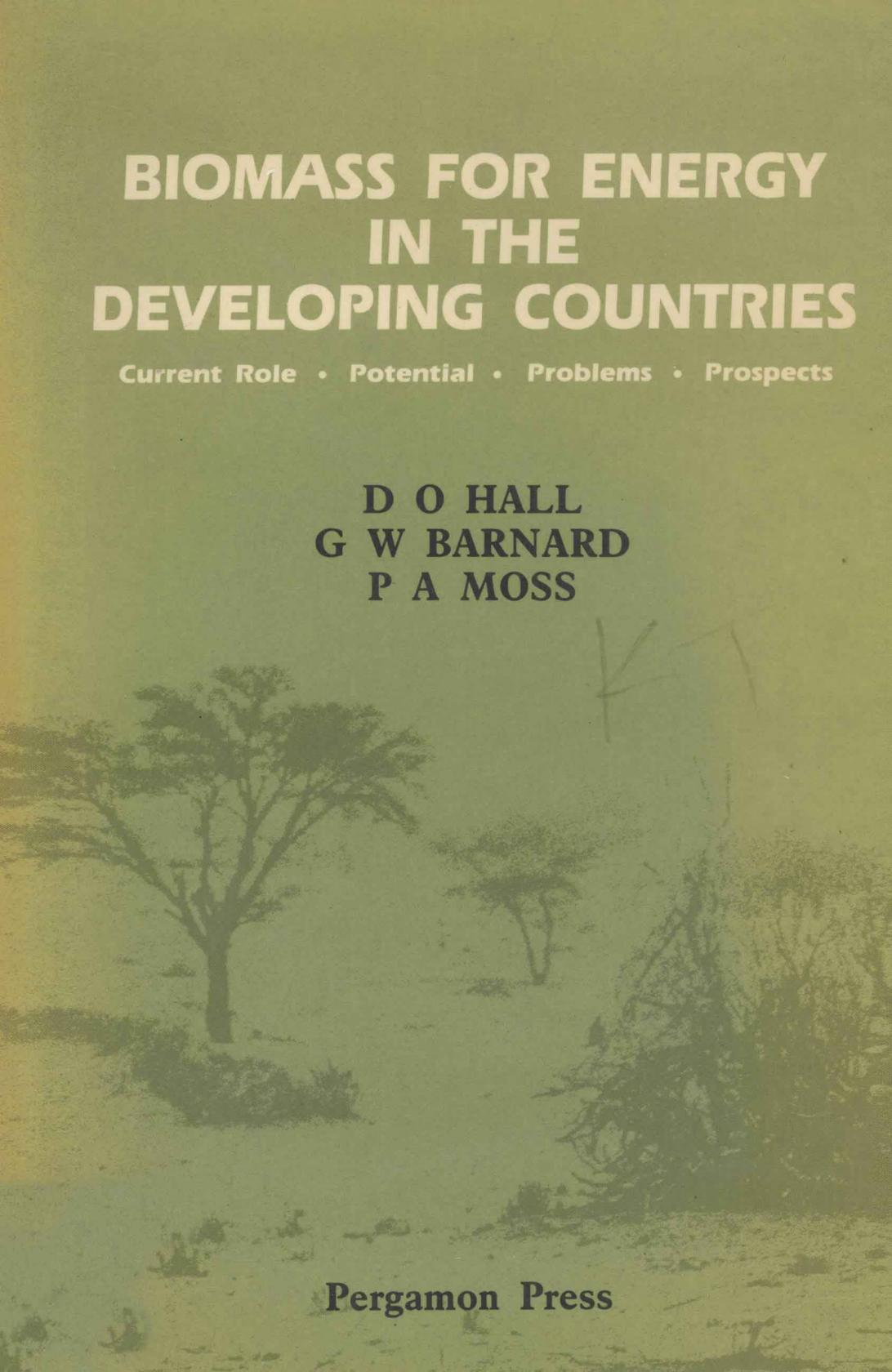


# **BIOMASS FOR ENERGY IN THE DEVELOPING COUNTRIES**

**Current Role • Potential • Problems • Prospects**

**D O HALL  
G W BARNARD  
P A MOSS**



**Pergamon Press**

# **Biomass for Energy in the Developing Countries**

**CURRENT ROLE, POTENTIAL, PROBLEMS, PROSPECTS**

by

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## **Preface**

The authors of this book have been actively involved in Biomass Energy research for several years and have worked with a variety of national and international agencies, including the United Nations and the Solar Energy Research Institute. So as to keep the costs of publication to a minimum, the authors have agreed to forego any potential royalties from the sale of this book. They welcome any comments and corrections with regard to the text and are particularly anxious to receive additional information on current Biomass Energy use in Developing Countries so that their data base can be continually improved.

# Summary and Conclusions

## I General Considerations

1. The importance of biomass energy in the developing countries today is indisputable. In many countries, biomass supplies more than half of the total amount of energy used and in some this reliance is as great as 95%.
2. These startlingly high figures result from the fact that the traditional biomass fuels - wood, charcoal, crop residues and dung - are still the primary cooking and heating fuels for the vast majority of the population of the developing countries, especially the rural and urban poor.
3. The role of biomass energy is in jeopardy, however. In many countries, biomass fuel supplies can no longer meet demand and for a variety of reasons, severe shortages are developing.
4. These problems, sometimes known as the 'second energy crisis', are superimposed on those caused by the rising price of oil. Despite their modest consumption levels, many of the developing countries have been hard hit by the oil crisis and are now facing acute balance of payments difficulties as a consequence.
5. Because of these dual energy problems, there is a clear need to develop indigenous energy sources in the developing countries - renewable as well as non-renewable. This is particularly urgent in view of the fact that expanding energy supplies will be necessary simply to maintain present levels of consumption for a growing population - let alone providing for the major increase in energy consumption that will be essential if economic development is to proceed.
6. Amongst the various options, there is significant scope for the development of biomass energy systems. Present biomass resources can be utilised more efficiently and a variety of approaches, new and old, are available for growing and using biomass for energy.

I General Considerations (contd)

7. For supplying commercial energy needs, a range of processes exist for producing convenient liquid, gaseous and solid fuels from biomass. Although they will not necessarily be cheap, in principle these could allow biomass energy to replace oil in each of its present roles. For individual countries, these options must be assessed in the light of local conditions and the availability of alternative energy sources - fossil fuels, hydro-power, etc.
8. For supplying domestic energy needs, on the other hand, there are very few viable alternatives to biomass. For the vast majority of the poorer sectors of the developing countries, locally grown biomass fuels are the only source of energy which is within their financial reach. This situation is unlikely to change in the near future since, without heavy subsidies, virtually all non-biomass alternatives - kerosene, bottled gas, etc. - are much too expensive to have any widespread impact, other than perhaps in towns. Developing low-cost methods of producing and using biomass energy is therefore of the highest priority if the future domestic energy requirements of the poor are to be met.
9. The biomass energy systems that are described in this book cover the whole spectrum of possible applications of biomass energy. The technologies involved form a large and heterogeneous group - ranging from simple wood stoves to large and highly sophisticated processes for converting biomass to liquid fuels. In this book, biomass systems are discussed under the headings : Energy for Domestic Needs, Energy for Rural Development, and Energy for Petroleum Replacement.
10. Because of the heterogeneous nature of biomass energy systems it is difficult to make generalisations about their properties or their potential. One feature that they do have in common, however, is the high degree to which they are interlinked with other factors - environmental, agricultural, socio-economic, and political.
11. It is vital that these interactions are understood from the outset since they are of crucial importance in determining the limitations on biomass energy systems, as well as their potential impact both good and bad.
12. Limitations on the use of biomass energy systems, for example, can occur for a number of technical and economic reasons. One of the most important of these constraints is the competition for land between food and fuel production. In many cases, the introduction of new biomass systems will also be restricted by lack of financial and other resources, and the absence of the necessary infrastructures, extension services, manufacturing capabilities and technical know-how.
13. Barriers to the implementation of biomass systems can also arise for a variety of other reasons, more related to social

I General Considerations (contd)

and political factors. Conflicts of interest can be a major problem, for example, in cases where present ownership and control over resources is unequal, and where the introduction of new systems is likely to benefit some groups more than others. Other factors which can slow down the rate of diffusion of new energy schemes include lack of perception of energy problems and general unwillingness to invest in systems which have not been fully proven.

14. One of the advantages of biomass energy systems, however, is that they often have the potential for yielding subsidiary benefits other than their simple effect on energy supplies. Some systems, for example, can help to improve the environment whilst others can provide a stimulus for rural development through offering a source of employment, income and energy in rural areas.
15. It is important to recognise, on the other hand, that none of these benefits is necessarily guaranteed. As with most other technologies, if they are applied without consideration of their possible environmental hazards, and without taking into account the needs of the local population, biomass systems can equally well have a negative impact - both in damaging the environment and in increasing the exploitation of rural areas and rural populations.
16. Assessing the potential of biomass energy in the developing countries and arriving at effective implementation policies, is undoubtedly a very complex task. There are many limitations and constraints to take into account, and many decisions to be made concerning the choice of systems, scale options and the implementation approaches to be taken.
17. Furthermore, there are a large number of unknowns involved in biomass energy development. Whilst some biomass systems have been tried and found to be successful under some conditions, others have yet to be tested on a large scale. In almost all cases, detailed local surveys and field testing will be essential since many of the relevant variables - social, economic and technical - are highly site-specific and because very little information generally exists with regard to current patterns of biomass energy use. Adaptation of systems to fit local conditions is also likely to play a crucial part in ensuring the success of biomass energy schemes.
18. Overall, biomass energy will not be a simple solution to the energy problems of the developing countries. Biomass systems will not necessarily be cheap, nor will they be implemented easily, without a major commitment from governments and a considerable amount of political will at the national and international level.

I General Considerations (contd)

19. The era of cheap oil and abundant traditional fuels is over, however, for practically all developing countries. Coming to grips with the fundamental problems that energy supply poses, and arriving at effective solutions, is one of the most vital tasks in the overall development process. In view of the urgency of the problems and the lack of viable alternatives, it is clear that biomass systems have an important role to play.

II Energy for Domestic NeedsA Nature and Cause of Problems

20. Many millions of people in the developing countries are now facing acute shortages of traditional biomass fuels. These shortages carry with them immense costs, both in human and environmental terms, although the economic costs are often indirect and hard to quantify.
21. The situation elsewhere in the developing countries, whilst not as serious yet, is rapidly deteriorating due to the combined effects of growing demand for traditional fuels and diminishing supplies.
22. The increase in demand for these fuels is closely related to population growth, but it is accentuated by urbanisation - which concentrates demands - and by oil price rises, which put alternative fuels out of the financial reach of the poor.
23. Whilst deforestation is certainly the major reason for the decrease in fuel supplies, fuelwood cutting is not the only cause of deforestation. Other factors that are often equally important in causing deforestation include the clearing of land for agricultural purposes, overgrazing by animals and uncontrolled logging. It is vital that the true causes of deforestation are appreciated if effective counter-measures are to be devised.
24. As well as fuel shortages existing in absolute terms, it should also be stressed that the hardship that they cause can be greatly increased through distributional inequalities. In cases where access to resources is in the hands of the wealthy, along with the ability to pay for alternatives, it is the poor who suffer most from fuel shortages.

B Possible Technical Solutions

25. To help reduce domestic energy problems in the developing countries a variety of approaches is possible. These centre around either increasing the production of biomass fuels or improving the efficiency of fuel processing and fuel use. The approaches that appear to have the greatest immediate potential are :

a) Better use of forest resources

In many countries, the simplest way of expanding fuelwood supplies is to increase the efficiency of utilisation of existing forest resources. This can include, for example, making fuller use of logging wastes, opening up new areas of forest for fuelwood extraction, relaxing legal constraints on forest use and promoting replanting. In each case it is

II Energy for Domestic Needs (contd)

essential that over-cutting is avoided so as to ensure the renewability of the resource.

b) Planting fast growing trees on unused land

This can be done on a large scale, to supply urban needs, or on a smaller scale for village/individual uses. It can be organised commercially, through forestry organisations, or on a communal or private basis. Where land is scarce, Agroforestry techniques can be useful since they permit food and fuel to be produced on the same piece of land. Planting multiple-use tree species can also help the economics of tree growing considerably. Leguminous trees have the added advantage of improving soil fertility.

c) Rationalisation of charcoal-making activities

Present methods of charcoal making are often extremely inefficient. Reasonably cheap medium-sized masonry or brick kilns can be used, however, which are twice as efficient as traditional methods. These can be profitably employed in commercial or community charcoal making operations where the necessary capital is available. Efforts to prevent over-cutting and promote replanting will also help to reduce the rate of deforestation caused by charcoal making and increase the renewability of charcoal supplies. The potential for introducing more efficient kilns to small-scale charcoal makers is not great, due to cost constraints.

d) Introduction of improved cooking stoves

Using locally available skills and materials, low cost cooking stoves can be made which are substantially more efficient than traditional stoves or open fires. If this increased efficiency could be translated into practice, under field conditions, it could lead to considerable fuel savings. For stoves to be accepted by users, however, they must be designed so that they match local cooking habits and are convenient to use with the available fuels. They must also fulfil the subsidiary requirements of present stoves and fires, such as room heating and keeping away insects. It should be noted that actual fuel savings may not be as great as predicted from laboratory tests since users may prefer to burn the same amount of fuel and simply use more heat.

e) Biogas

The production of biogas from animal dung and other organic wastes has a number of theoretical advantages in that it produces a fuel that is well suited for cooking and lighting purposes whilst retaining nutrients and improving hygiene. The use of household biogas plants will probably be limited in many cases, however, by the relatively high costs of the plants and the shortage of suitable feedstock materials, particularly for the poor. Cultural considerations are also important in determining the acceptability of using dung and human wastes for fuel. To reduce capital costs and increase the scope of biogas technology so that poorer members of the community can contribute - and

II Energy for Domestic Needs (contd)

benefit - larger scale communal plants have some potential. These will require a substantial degree of village cooperation, however, if organisational and distributional problems are to be avoided.

C Socio-economic and Political Considerations

26. The technical feasibility of the various household energy schemes mentioned above will vary tremendously from location to location, depending on factors such as land-use practices, agro-climatic conditions, population density and competing uses for biomass resources.
27. Equally important, however, are the many socio-economic and political factors which impinge upon present fuel-use practices - and which will have a direct effect on the rate of diffusion of new energy schemes and their subsequent impact.
28. Some of the most important of these considerations are listed as follows :
- The level of perception of energy problems and the importance of traditions in fuel collection and fuel use practices - and the logic behind them
  - Poverty and the general shortage of land, capital and other resources necessary for investment in new energy systems
  - Competition for use of resources with other activities
  - Constraints on the choices open to individuals due to the importance of short-term considerations, and the avoidance of risk, as opposed to long-term needs
  - Unequal land distribution at the village level and inequalities in the ownership of resources, access to credit and general political and economic power
  - Conflicts of interest between members of the community over the distribution of costs and benefits from new energy schemes
  - The value placed on non-financial benefits from new energy systems
  - The involvement of women in the decision making process

II Energy for Domestic Needs (contd)D Requirements for Successful Implementation

29. Given the complexity of many of these issues, it is vital that the perceptions of potential users - and the problems and constraints facing them - are fully understood in attempting to devise effective domestic energy strategies. This understanding can often only come through a close interaction with the people involved.
30. For this reason, a 'bottom up' approach to the diffusion of new energy systems is generally much more likely to succeed than a 'top down' approach in which people's needs are assessed from outside and then efforts are made to design and diffuse 'appropriate' energy solutions to solve their problems.
31. A 'bottom-up' approach is not easy to achieve in practice, however. It involves organising and assisting people to solve their own problems - by defining their own energy needs, developing locally acceptable responses (technical and organisational), and carrying out mutually agreed programmes.
32. Cooperation is obviously vital, but for this to be forthcoming people must view energy schemes as being for their benefit. Developing confidence in government extension services is a crucial part of this, and a combination of persuasion, demonstration and suitable incentives may often be required to bring about the necessary transition in people's attitudes. Employing women extension officers can be helpful in this context, in encouraging the participation of women in developing and carrying out energy programmes.
33. Building up effective extension services will be a problem in almost all developing countries. It is, however, an essential part of the process of developing and diffusing domestic energy schemes, since market forces have generally failed to produce viable long-term solutions to the energy problems of the poor.
34. In summary, the domestic energy problems of the developing countries are often extremely intractable. Present energy-use practices are an integral part of everyday life and, as such, are closely tied with the basic problems of poverty and inequality. These practices will not change overnight, nor will the problems disappear without a considerable degree of commitment, imagination and action from national governments. These matters must be given highest priority, however, since if domestic energy problems are not tackled now the price to pay later both in economic terms, and in human hardship, is sure to increase.

III Energy for Rural DevelopmentA Background

35. Providing a sustainable and affordable energy source is an important component of rural development. Coupled with other inputs - financial, technological, etc. - a relatively small increase in energy use can bring with it substantial improvements in agricultural productivity and can permit growth in rural industries and public services.
36. Biomass energy systems have particular potential in this context, due to their versatility and suitability for decentralised rural applications. Simple and relatively low-cost conversion devices are available that can supply all forms of rural energy demands, providing that a suitable source of biomass is available and given that moderate levels of mechanical skills exist for operation and maintenance.
37. Costs, in some cases, are already competitive with conventional commercial fuels and as oil prices rise biomass systems should become increasingly attractive.

B Technical Options

38. Biomass fuels - wood, charcoal, sawmill wastes, etc. - are already used to a substantial degree for providing heat for rural industries. This use could be expanded considerably providing that suitable biomass sources exist.
39. For supplying mechanical energy needs the approaches that appear to have the greatest immediate potential are :

a) Gasifiers

Small-scale gasifiers can be built using simple materials, enabling dry forms of biomass (wood chips, rice husks, corn cobs etc.) to be converted to a low energy gas suitable for use in diesel engines - mobile as well as stationary. Diesel consumption can be reduced by up to 80% but careful maintenance is required to ensure smooth operation.

b) Biogas

Animal dung, various organic wastes, and certain types of degradable plant matter can be converted to biogas (a methane/carbon dioxide mixture) through anaerobic digestion. This can also be used as a supplementary fuel for diesel

III Energy for Rural Development (contd)

engines although its use will be generally limited to stationary power applications due to the problems of gas storage.

c) Steam Engines

This is a well-tried alternative for using wood for medium-large scale mechanical power applications which could be revived.

d) Liquid Fuels

The simplest approach to producing liquid fuels on a small-scale local level is to grow crops such as oil palm, coconut, sunflower and sesame from which vegetable oils can be extracted. These can be used directly as a diesel extender and with relatively minor treatment can be used indiluted. There is also considerable potential for the small-scale production of ethanol from sugar or starch crops although there has been little experience in this area as yet.

e) Draught Animals

These are the traditional method of supplying mechanical power in rural areas. They have many advantages and the potential that exists for increasing their use should not be ignored.

40. The most important technical limitation on the use of these systems arises in the supply of adequate quantities of biomass materials. Some of the key considerations in this context are as follows :

- Competition for land use
- Competition between using biomass for food, fuel or other purposes
- Competition between commercial and domestic uses of biomass fuels.

41. New biomass systems are unlikely to be accepted if they are unprofitable, but it is vitally important that expanding the use of biomass for new rural applications does not have the effect of increasing domestic fuel shortages, or creating further environmental damage.

42. Possible options for increasing biomass supplies include the following :

- Increasing the use of waste products from agriculture and rural industries

III Energy for Rural Development (contd)

- Growing trees or other energy crops on unused land
- Use of improved agricultural techniques so as to increase both food and fuel production
- Use of Agroforestry techniques.

43. In almost all areas, a significant increase in biomass production is theoretically feasible and in principle this could allow a substantial degree of energy self-sufficiency in rural areas to be attained. Energy is not the only input that is required, however, and in practice it will often be the lack of financial resources, technical know-how and other essential inputs which limit the impact of biomass energy systems.

C Social Considerations

44. Organisational inputs can also be important, since encouraging individuals and communities to work together in pooling resources and skills is often a prerequisite for maximising production efficiency. Where conflicts of interests are strong, achieving this mutual cooperation may be very difficult.

45. It should also be recognised that increasing the productivity of rural areas through the expansion of energy supplies will not in itself guarantee an equitable distribution of the benefits. If new energy devices are used to displace labour, for example, this can create severe problems for poorer sectors of the community who often rely on hiring out their labour to earn a living.

D Implementation

46. Most of the uses of biomass energy mentioned in this category have the potential of yielding a direct financial benefit to the user either in the form of increased agricultural or industrial productivity, or as decreased energy bills. It is likely, therefore, that market forces will be more effective in diffusing these technologies than for domestic energy systems - which only yield indirect benefits such as increased convenience.

47. National governments have an important role to play, however, introducing these biomass systems. Some of the more crucial government roles include :

- Provision of credit facilities and other incentives
- Performing research and development work