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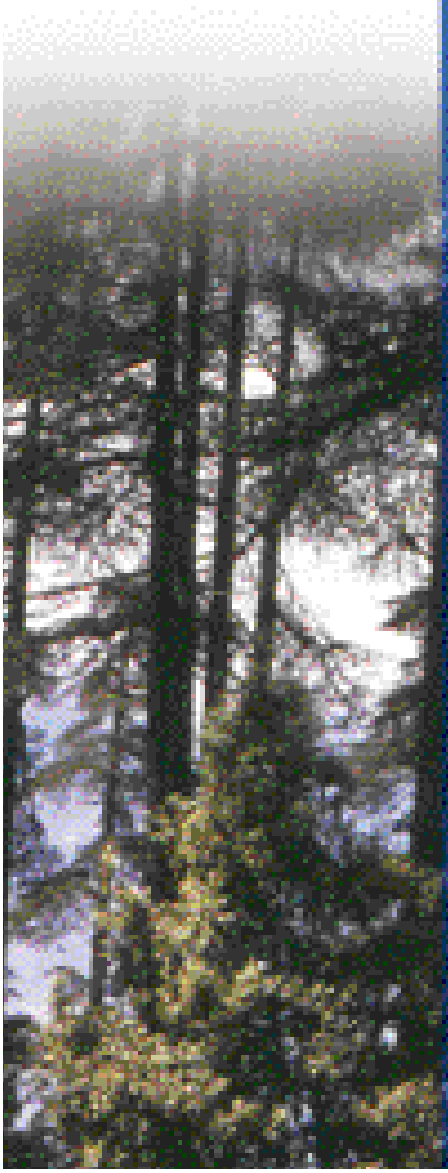
Clean Energy for Development and Economic Growth : Biomass and Other Renewable Energy Options to Meet Energy and Development Needs in Poor Nations

Policy Discussion Paper for the Environmentally Sustainable Development Group (ESDG) of the United Nations Development Programme (UNDP)



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Acknowledgments

The authors would like to thank our colleagues at the University of California at Berkeley: Barbara Haya, John-O Niles, Tracey Osborne, Sergio Pacca, and Emily Yeh of the Energy and Resources Group, Sumi Mehta and David Pennise of the School of Public Health and Laura Kueppers of the Department of Environmental Science Policy and Management for useful discussions and contributions. We also thank each of the case study authors for the quality and the speed with which they were able to assemble their material. In addition, Sivan Kartha and Rick Duke both provided an invaluable set of observations and recommendations. We also thank Richard Hosier, Arun Kashyap and other members of the Environmentally Sustainable Development Group of the United Nations Development Programme (UNDP), who provided useful comments on earlier drafts. Lastly, we acknowledge with thanks the helpful comments we received on the first draft of this publication, including suggestions from Elsen Karsted of Chardust Ltd., in Nairobi, Kenya, Dean Still of the Aprovecho Institute, and Stephen Karekezi of the African Energy Policy Research Network (AFREPREN). We thank the UNDP, the Energy Foundation and the Link Foundation for support. Needless to say, any errors and omissions are the sole responsibility of the authors.

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Executive summary

This paper explores the linkages between renewable energy, poverty alleviation, sustainable development, and climate change in developing countries. In many developing countries, the lack of access to convenient and efficient energy services is a major barrier to achieving meaningful and long-lasting solutions to poverty. Of course, providing quality energy services will not, in itself, eliminate poverty. Nevertheless, when poor people and communities obtain access to convenient and efficient energy

services, one major barrier to poverty reduction can be lowered or removed. **Renewable energy technologies using biomass, wind, solar, hydropower and geothermal energy sources can provide energy services for sustainable development based on indigenous sources, with almost no net emissions of greenhouse gases.**

In most developing countries, **conventional approaches to energy service provision – state-run utilities and extension of the national electrical grid – have not proven successful**. To date, most developing countries have financed their energy sectors with loans from bilateral and multilateral lending institutions. For various reasons, these institutions have heavily favored fossil fuel and large hydroelectric power, which have left developing countries with large burdens of debt and taken a significant toll on the local and global environment, while providing only a small fraction of people with adequate energy services.

Poor families in developing countries still rely on traditional fuels – wood, crop residues and dung – for cooking, heating and productive activities. They are limited in their ability to do more than satisfy basic needs. The lack of access to clean and convenient energy services in rural areas limits economic opportunities and drives people, most frequently male household members, to seek employment in towns and cities. This leads to increasing numbers of female-headed rural households, and adds to the burdens on poor women and children, who already expend a great deal of effort in gathering wood and other traditional fuels, as well as meeting the other subsistence needs of the household.

Unsustainable use of traditional biomass fuels is associated with significant health and environmental costs. Smoky, unvented fires for cooking and heating lead to high concentrations of indoor air pollution which cause acute respiratory infections, tuberculosis, adverse pregnancy outcomes, and lung disease. Women who are doing the cooking, and their young children, are the ones who are most affected. Open fires also contribute to atmospheric accumulations of greenhouse gases, particularly carbon dioxide. Deforestation adds to fuel wood scarcity and environmental degradation, and limits carbon dioxide absorption by trees.

Policies that focus on small-scale decentralized renewable energy systems, coupled with greater access to information, technical training, credit and markets, have the potential to succeed in promoting sustainable development, including economic opportunities and environmental protection, where conventional approaches have failed. Recent technical advances in renewable energy-based power generation, accompanied by rapid growth in production and dramatic reductions in costs, place renewable energy technologies in a favorable position in comparison with conventional fossil fuel systems, in an ever-expanding variety of applications.

A combination of sound national and international policies and genuinely competitive markets – the so-called level playing field – can be used to promote clean energy systems. However, there still remain numerous technical, social and market barriers, on the local as well as global level, preventing wider deployment of renewable energy systems. Such barriers must be understood and dismantled in order to take advantage of the social and environmental benefits of a shift from conventional to renewable technologies. Renewable energy sources have had a difficult time breaking into markets dominated by large-scale, fossil fuel-based systems. In part this is because renewable energy technologies are only now being mass produced, and have had high capital costs relative to more conventional systems. It is also partly because coal, oil and gas-powered systems, as well as large hydroelectric dams have all benefited from a range of subsidies over the years.

Renewable energy technologies tend to be characterized by low environmental costs which, in an ideal world, would help them compete with conventional technologies. But, of course, many of these environmental costs are "externalities" that are not priced in the market. Further internalization of these costs, through the provisions of the Kyoto Protocol and other energy and climate change policies, would encourage the spread of renewable energy systems.

Our discussion includes all types of renewable energy technology, but **we place special emphasis on biomass-based energy systems**. While biomass fuels are likely to remain the primary energy source for most poor people, improved stoves and cleaner fuels can reduce fuel requirements and adverse health and environmental impacts. Meanwhile, improved technologies for use of biomass in small commercial and industrial applications can make modern energy installations economically viable in rural and peri-urban areas of developing countries, since businesses have larger energy demands than households and are better able to mobilize capital.

Biomass energy has a number of unique attributes that make it particularly suitable to climate change mitigation and community development applications. Biomass fuel sources are readily available in developing countries, particularly in rural areas, and do not have to be imported. Biomass-based industries can be a significant source of jobs in rural areas, and sustainable land management activities can promote biomass regrowth, allowing more carbon dioxide to be absorbed from the atmosphere. [See box on the benefits of bioenergy.]

By promoting biomass energy to provide clean and efficient "modern" energy services in the form of solid, liquid, and gaseous fuels as well as electricity, the governments of developing countries can address many of the negative aspects of current unsustainable biomass consumption. Moreover, taking that step now does not require devoting large amounts of land to bioenergy crop production, which can potentially conflict with other land uses, particularly food-crop cultivation. Significant amounts of energy can be derived from underutilized agricultural, agro-industrial, and timber wastes, which include bagasse from sugarcane processing, sawdust and off-cuts from the timber industry, fruit pits and prunings from orchards, coffee husks, rice husks, and coconut shells. Using these resources for energy generation would allow countries to gain valuable experience through learning-by-doing while continuing with basic research in energy crop production.

A variety of technologies can convert solid biomass into cleaner, more convenient energy forms such as gases, liquids and electricity. Direct combustion remains the most common technique for deriving energy from biomass for both heat and electricity. Advanced domestic heaters obtain efficiencies of over 70 per cent with greatly reduced atmospheric emissions. Electrical power is commonly generated in steam cycle plants often located at industrial sites where the waste heat from the steam turbine can be recovered and used in industrial processing. Combined heat and power systems provide higher efficiencies than systems that only generate electricity.

Combustible gas can be produced from biomass through a high temperature thermochemical process - gasification - that involves burning biomass without sufficient air for full combustion, but with sufficient air to convert the solid fuel into a gas. The resulting gas can be burned directly for cooking and heating uses, or used in internal combustion engines or gas turbines for producing electricity or shaft power. The systems range from small-scale technologies suitable for household or village use, to large grid-connected power or combined heat and power facilities.

Combustible gas can also be produced from biomass through the biological processes of anaerobic digestion, either in specially-designed digesters or in landfills. This biogas can be used to provide energy for cooking and space heating, and to generate electricity. Biogas digesters have been widely adopted in India and China, and other developing countries.

Liquid fuels produced from solid biomass can be used to replace petroleum-based fuels. The most widely produced liquid biofuel today is ethanol, which can be produced from fermentation of any carbohydrate crop. Sugarcane and corn (maize) are the most common ethanol feed stocks though cassava, sorghum, and other root crops have also been considered.

Conversion of biomass to energy carriers like electricity and transportation fuels can give biomass a significant commercial value and potentially provide income for rural economies. But transforming bioenergy into a renewable source of high-quality fuels and electricity will not happen without the establishment of enabling policy environments and adequate public and private sector investment.

In addition to the lack of energy services, which limits opportunities for many people in developing countries, there are numerous environmental problems associated with energy development. These problems are both local and global in nature. Among the most pressing of these environmental problems is global climate change. Policy makers in many developing countries are aware of the need for climate change mitigation, but they are generally more concerned with providing basic services to populations, including energy, as well as clean water and basic health care and education. They also hold that the industrialized countries have been emitting greenhouse gases for well over a century and should bear the brunt of the costs of climate change mitigation.

The Kyoto Protocol to the UN Framework Convention of Climate Change recognizes the responsibility of industrialized countries to take the lead in reducing greenhouse gas emissions. Currently, most of the greenhouse gases added to the atmosphere by human activities are the result of carbon dioxide from fossil fuel combustion. Over two thirds of those emissions come from industrialized countries. But greenhouse gas emissions are increasing in developing countries much faster than in industrialized countries as a result of growth in both population and national economies. **If developing countries follow the path taken by industrialized countries in building energy generation infrastructure, they will likely exceed industrialized countries in net greenhouse gas emissions within one or two generations**. And if that path continues without a significant shift toward renewable-based energy generation, there will be little hope of stabilizing greenhouse gas accumulations even if industrialized countries meet the modest goals set by the Kyoto Protocol.

The Clean Development Mechanism (CDM) under the Kyoto Protocol offers a means through which industrialized countries can work towards compliance with their commitments to reduce greenhouse gas emissions by supporting sustainable development projects in developing countries. It is likely that a number of CDM projects will target the

energy sector, as well as land use and forestry activities. **Biomass energy projects can meet the requirement of fostering sustainable development, due to their numerous positive environmental and social impacts, including improvement of degraded lands, creation of employment opportunities and raised living standards for poor communities.**

In order to ensure that CDM projects in fact promote sustainable development as well as climate change mitigation, projects must be guided by meaningful public participation and local benefit-sharing policies. Clear guidelines are needed so that the many competing uses of land areas supporting biomass projects are considered, including the livelihoods of indigenous and marginalized communities, different ethnic groups, and women. In addition, in order to establish a critical knowledge base for sound and profitable bioenergy management, there needs to be a collaborative partnership among researchers, governments and industries in developing as well as industrialized countries. **Lessons can be drawn from joint UNDP and World Bank efforts in climate change mitigation projects under the Global Environmental Facility, and from case studies such as those included as part of this document.**

Biomass and bioenergy – advantages for climate change mitigation and poverty alleviation:

Local resources: Biomass energy systems rely primarily on locally available resources and eliminate the need for imported fuels

Participation: Local nature of fuel supply can encourage local participation through job creation and fuel supply contributions, as well as local ownership, investment, and project management

Jobs: Biomass energy production is relatively labor intensive and the stages of energy production provide far more local jobs, skilled and unskilled, than comparable energy technologies

Flexibility and multiple use: Biomass energy generation can be based on a variety of feedstocks which allow for multiple crops to be grown. Land used to produce bioenergy crops can support multiple uses in order to meet changing local needs.

Stores carbon: standing stocks of biomass store carbon above-ground, below-ground, in leaf litter, and in the soil. The overall carbon accounting strongly depends on what the prior land use was.

Land degradation: If bioenergy stocks are planted on degraded lands, they have the potential to bring long-term improvements in soil quality and fertility.

Ecosystem services: Growing biomass can provide numerous ecosystem services including the control of soil erosion, sustaining the hydrological cycle, and providing habitat for wildlife.

Introduction: Renewable energy, global warming and sustainable development

Conventional energy sources based on oil, coal, and natural gas have proven to be both highly effective drivers of economic progress, and damaging to the environment and to human health. Perhaps the gravest challenge currently associated with energy use in all nations is the need to reduce greenhouse gas emissions.

The potential role of renewable energy technologies in transforming global energy use, and addressing climate change concerns, is enormous. Energy sources such as biomass, wind, solar, hydropower, and geothermal can provide sustainable energy services, based on a mix of readily available, indigenous resources that result in almost no net emissions of greenhouse gases.

The costs of solar and wind power systems have dropped substantially in the past 30 years, and continue to decline. The economic and policy mechanisms that support the widespread dissemination and sustainable markets for renewable energy systems have also rapidly evolved. Future growth in the energy sector will be primarily in renewable technologies and, to some extent, natural gas-based systems, rather than in conventional oil and coal-based sources.

Renewable energy systems are usually implemented in a small-scale, decentralized model. As an alternative to centralized power plants, which require customized onsite construction, renewable systems based on solar photovoltaic (PV) arrays, windmills, biomass or small hydropower, can be mass-produced at low cost and tailored to meet specific energy loads and service conditions. These systems also have fewer environmental impacts than larger, more centralized power plants that, in some cases, have contributed to serious ambient air pollution and acid rain, as well as global climate change.

In developing countries, heavy reliance on imported fossil fuels also represents a huge financial burden. Energy sector development in developing countries, with few exceptions, has focused on large hydro systems and fossil fuels, despite the fact that many developing countries are rich in biomass, wind, solar, and smaller, less environmentally and socially disruptive hydro resources that could power their economies and improve their living standards.

Renewable energy sources currently supply somewhere between 15 per cent and 20 per cent of the world's total energy demand, mostly in the form of fuelwood used for household energy needs in developing countries. New renewable energy sources (solar energy, wind energy, modern bio-energy, geothermal energy, and small hydropower) currently

contribute about two per cent of the global energy mix. Studies indicate that in the second half of the twenty first century their contribution might increase dramatically, with the right policies in place. This will only occur, however, if energy projects and policies are evaluated and implemented based on their overall social, economic, and environmental merits.

Use of bioenergy resources in developing countries can build local capacity to meet energy needs, and also provide significant employment and development opportunities.

This document provides a resource guide on biomass and other renewable energy options, case studies, and a set of recommendations for international energy and climate policy organizations, national governments, non-governmental groups, and local communities.