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Acknowledgements

This publication consolidates and synthesizes two more comprehensive studies commissioned by FAO in 2007 and published as working papers. They are *Forests and energy in developing countries* by Ivan Tomaselli and *Forests and energy in OECD countries* by Warren Mabee and Jack Saddler. These papers can be found at www.fao.org/forestry/energy. A draft version of the consolidated paper, prepared by Douglas Kneeland and Andrea Perlis, was distributed at the FAO Conference Special Event: Forests and Energy in November 2007. The present edition, prepared by Jeremy Broadhead and edited by Maria Casa, incorporates comments received from member countries. Miguel Trossero, Simmone Rose, Sebastian Hetsch and Gustavo Best also contributed.

Foreword

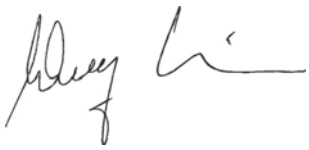
Forests and energy are at the centre of the global debate on climate change. This publication addresses some of the most important trends in both these sectors to enlighten the debate.

The paper draws upon two comprehensive studies commissioned by FAO in 2007: *Forests and energy in developing countries* (Ivan Tomaselli, Brazil) and *Forests and energy in OECD countries* (Warren Mabee and Jack Saddler, Canada). These working papers are available in English on the FAO Web site at www.fao.org/foresty/energy.

Up until 100 years ago when petroleum became widely available, wood was the most important source of energy for human beings. In many of the world's poorest countries, wood remains the primary source of energy for heating and cooking. In this study, we look into the future and see that wood is once again likely to emerge as a very important source of energy in all countries.

Bioenergy from wood and agricultural sources will regain its importance. Agricultural and forest crops play a particular role in modern bioenergy generation as sources of liquid biofuels. While fossil fuels are likely to remain the dominant source of energy for some time to come, a long-term and gradual partial conversion from fossil fuels to solid and liquid biofuels is an increasingly likely scenario for many countries in the coming decades. Will these trends have an impact on forests? Will they result in more or less forest in the future?

This publication explores these questions and more as a contribution to informed policy discussions. It outlines potential opportunities and impacts in relation to forestry in the context of growing global energy demand. Expected changes in global energy supply and the position of renewables and forest energy within this are discussed in Section 2. Aspects of bioenergy production are summarized in Section 3, and Section 4 reviews the possible contribution of forest energy to global energy consumption in the coming years. Section 5 examines the implications of increased consumption of bioenergy on forests, and Section 6 outlines policy options and recommendations in light of the opportunities and threats to forestry.



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Executive summary

Soaring energy consumption, increasing greenhouse gas emissions and concerns over energy import dependence are prompting global changes in the sources from which energy is expected to be derived in the coming years. Energy consumption is projected to increase at the highest rates in developing countries and particularly in Asia. Fossil fuels are expected to account for the bulk of the increase in energy supply. Although per capita levels of consumption will remain below those in the industrialized world, energy consumption in developing countries is expected to surpass that of developed countries by 2010.

Alternative forms of energy are receiving considerable interest as a means to reduce fossil fuel consumption and limit greenhouse gas emissions. Bioenergy, including wood energy, constitutes a large proportion of current supply from "renewable" sources of energy. In spite of the recent oil price increases, it is unlikely that markets alone will support a major reorientation towards renewables and future consumption will therefore depend largely on policy measures.

Wood energy has been used for thousands of years for cooking and heating. In many of the world's developing countries, it remains the primary source of energy and in much of Africa total consumption of woodfuel is still increasing, largely as a result of population growth. In other developing regions consumption at the national level is generally falling as a result of rising levels of income and increasing urbanization – two factors which lead to increased use of more convenient fuels. In industrialized countries and particularly countries with large wood processing industries, wood energy is used for both domestic and industrial purposes – often in significant amounts.

Wood energy produced with efficient technology is already competitive with fossil energy in many countries and can offer some of the highest levels of energy and carbon efficiency among bioenergy feedstocks. Most notably, combined heat and power plants have conversion efficiencies of up to 80 percent and wood pellet stoves have similarly high rates of conversion. It is expected that technology will also be available in the medium-term for commercially competitive production of liquid biofuels from cellulosic materials including wood, although costs associated with patents and royalties may hold back development. Liquid biofuels are currently produced mainly from food crops and economic and carbon efficiencies are mostly low. The notable exception to this rule is the production of ethanol from sugar cane. In Brazil, bioethanol prices are already below those for petroleum based transport fuels.

It is expected that production of second-generation liquid biofuels made from wood and other cellulosic feedstocks will be similarly competitive, both in terms of price and carbon emissions. Second-generation biofuel production is already under way in demonstration plants and commercially competitive production is expected

to be in reach within the next decade. Most studies project that second-generation liquid biofuels from perennial crops and woody and agricultural residues could dramatically reduce life cycle greenhouse gas emissions relative to petroleum fuels. If technological developments make it more efficient and at least as economical to produce liquid biofuels from cellulosic material rather than from food crops, the result would be reduced competition with food production, an increase in energy efficiency and improved overall energy balance.

In the longer-term, biorefineries producing a range of products from wood pulp to transport fuels and specialized chemicals may become more widespread – especially in countries with sizeable wood processing industries, efficient business environments and effective policy implementation. Opportunities may also exist for export of transport fuels made from cellulosic materials to large high-paying markets. Associated increases in demand for wood are likely to push up prices until markets are able to re-equilibrate. Sawlog and pulp log prices, as well as wood panel prices are likely to be most affected and, indeed, prices are already responding in some markets.

With increasing demands on land from first-generation liquid biofuel development, pressure on forests is likely to increase around the world. The opportunity costs of forests are likely to be too high in many cases to prevent conversion to bioenergy crop production if markets develop in line with recent trajectories. Where measures to protect and sustainably manage forests are ineffective or not upheld, forest clearance may result. Extensive degraded lands available in many developing countries have also been suggested as areas for potential expansion of bioenergy plantations. To realize these benefits, however, the expansion of biofuel production will need to be accompanied by clear and well enforced land-use regulations, particularly in countries with tropical forests at risk of conversion to other land uses.

The attractiveness of markets, supported by bioenergy policies is already leading to forest clearance for the establishment of oil-palm and other crops used to produce liquid biofuels. Policy objectives related to climate change are unlikely to be reached as the amount of carbon released in land clearance may be much higher than can be recaptured by the bioenergy crop in many years. The situation is even more serious where peat lands have been cleared. In this context, it is important to note that bioenergy can only be considered renewable if biomass growth exceeds harvest, and carbon dioxide emitted during production, transportation and processing does not exceed that captured during growth. Carbon losses associated with conversion of land for bioenergy production should also be taken into account.

The extent to which wood energy will contribute to future energy production is likely to depend on: the competitiveness of wood-based energy in reaching the objectives of recent energy related policies; the costs and benefits of wood-energy-related systems in social, economic and environmental terms; and policy and institutional issues that provide the framework within which forestry acts. The potential of any bioenergy strategy will also be highly influenced by local context including: location relative to supply and demand; infrastructure, climate and soil; land and labour availability; and social and governance structures.

At present, wood energy is most competitive when produced as a by-product of the wood processing industry. Wood residues provide possibly the greatest immediate opportunity for bioenergy generation given their availability, relatively low-value and the proximity of production to existing forestry operations. Wood residues from felling and processing operations generally constitute more than half of the total biomass removed from forests.

In natural forests, up to 70 percent of total volume may be available for energy generation. Most of this material is made up of tree crowns and other rejected pieces that are left in the forest after harvesting operations. Wood residues from mills represent another, more easily accessible source of residues.

Forest plantations established solely for the purpose of energy production are becoming more common in some countries and it is likely that plantations with multiple end uses may provide logs for wood fuels as well as logs for other purposes as markets demand. Species not currently favoured by markets, areas of logged over forest, and trees outside forests provide addition potential sources of wood for energy outside the commonly marketed, and therefore, more highly priced categories of forest products.

Especially where human and financial resources are limited, bioenergy development should first explore opportunities based on already available biomass and proven technology. Integrating energy generation into industrial forest operations is a competitive way of reducing risks, increasing profitability and improving forest management. It also strengthens energy security and contributes to climate change mitigation and should thus be a priority area for exploration.

To ensure that sufficient cropland is available to produce food at affordable prices and to avoid loss of valuable habitats, it is imperative that bioenergy strategies are closely linked with, and integrated in, agriculture, forestry, poverty reduction and rural development strategies. Land-use planning and monitoring, as well as effective governance can play an important role in avoiding some of the social and environmental problems that are already being reported. All countries would benefit from better information about wood energy feedstocks, including biomass recovered from forest operations and trade of forest biomass.

Policies and programmes to support bioenergy development are still in their infancy. In relation to forestry the following issues need to be addressed first:

- sustainable mobilisation of wood resources in relation to legal and institutional constraints, forest ownership, data access, forestry infrastructure;
- supportive laws, regulations and policies; information dissemination to forest owners, entrepreneurs and other actors;
- efficiency gains through more intensive use of existing forest resources, of forest harvesting and processing residues, of woody biomass from trees outside forests, and of postconsumer recovered wood products;
- long-term expansion of the forest area and enhancements in the productivity of forest resources, for example, through silvicultural and genetic innovation;
- the potential use of marginal and degraded land to produce biomass for energy generation.

Transfer of advanced wood energy technologies to developing countries will be very important in relation to climate change objectives. The present situation represents a major opportunity and challenge for the forestry sector to find a new role in securing energy supply, mitigating climate change and supporting sustainable economic and environmental development.