Economics of wood energy

In the past decade, policies to encourage the use of renewable energy have grown in importance as part of the efforts to reduce dependence on non-renewable energy sources such as fossil fuels and as part of strategies to address global warming. Wood energy has been identified as a potentially significant source of renewable energy, and for this reason a number of developed countries have shown interest in increasing its use (Trossero, 2002). In addition, wood energy remains the most important source of energy for the more than two billion people in developing countries who have access to few other sources of energy.

Given the importance of wood energy in developing countries and its potential importance in developed countries, it is useful to understand the economic forces that encourage or constrain the use of wood energy. This chapter provides an overview of wood energy and its importance, explains some of the economic forces affecting wood energy production and consumption and describes how countries might develop the wood energy sector to meet some of their broader policy goals and objectives.

OVERVIEW OF WOOD ENERGY

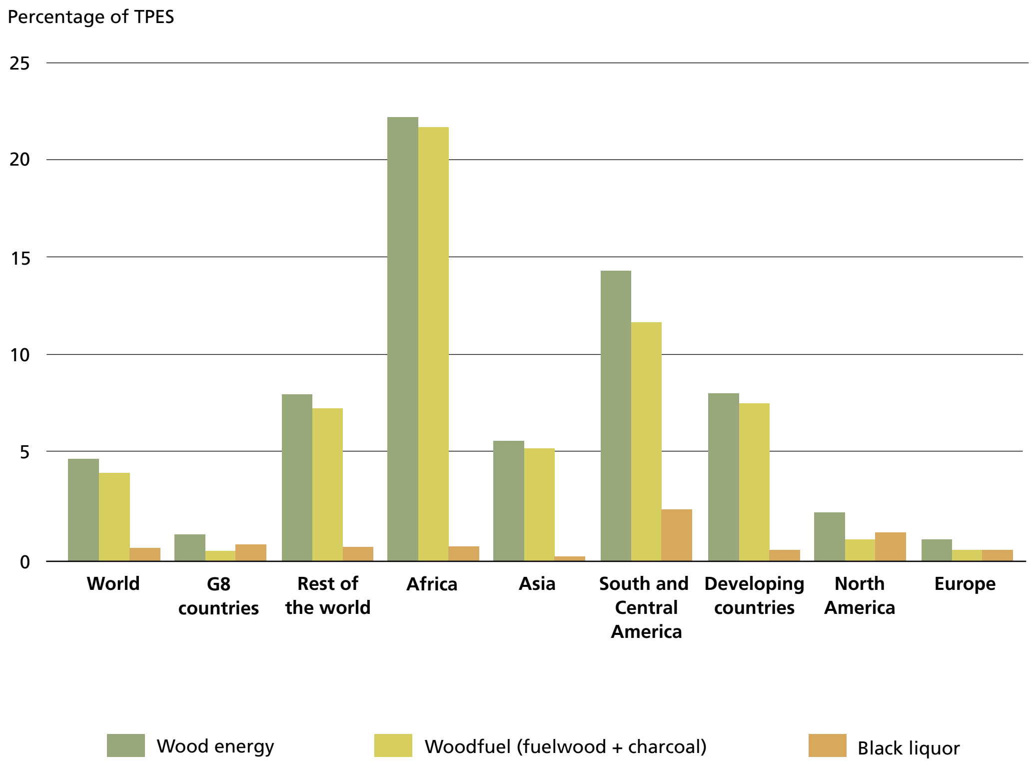
Wood energy comprises a number of different types of wood-based fuels. The most prominent of these is fuelwood, cut directly from trees and forests. This may be further refined into other types of energy such as charcoal or wood-derived liquid fuels. In addition to these, wood energy includes a number of by-products from the forest processing industry (notably black liquor – a by-product of pulp and paper making – and wood residues) and recycled wood and paper. It should also be noted that the wood energy sector includes more than just fuelwood and charcoal.

Currently, wood energy accounts for about 5 percent of the world's total primary energy supply (TPES)[1], and woodfuel is by far the most important source of wood energy (Figure 12). However, the importance of wood energy to total energy supply differs greatly among countries and regions. For example, wood energy (mostly fuelwood) accounts for more than two-thirds of TPES in the Congo, Eritrea, Ethiopia, Mozambique and the United Republic of Tanzania, and it accounts for over half of TPES in Haiti, Nepal and Paraguay. In Europe, the overall contribution of wood energy to TPES is very low (around 1 percent), but there are great differences among countries. For example, because of the large pulp and paper industry and the use of black liquor for energy production, wood energy accounts for 14 and 10 percent of TPES in Finland and Sweden, respectively (Table 10).

The importance of wood energy as a use of forests and trees also varies widely among countries and regions. Overall, woodfuel (i.e. fuelwood and charcoal) accounts for about 53 percent of total roundwood produced in the world. However, woodfuel accounts for only 14 percent of total production in G8 countries, compared with 69 percent in the rest of the world (Table 11). In terms of the distribution of woodfuel production across regions, Asia accounts for the largest share of global woodfuel production (around 44 percent), followed

[1] Total primary energy supply is the supply of unprocessed fuels (e.g. oil, gas and coal) and excludes the production of refined or converted types of energy (e.g. petrol and electricity). The figures presented here have been calculated by converting all of the different types of fuel into comparable measures of the energy that they can produce.

FIGURE 12
Contribution of wood energy to total primary energy supply, 2001



Source: International Energy Agency, 2003.

TABLE 10
Contribution of wood energy to total primary energy supply in selected developed countries, 2001

Country	Contribution to TPES (%)	
	Black liquor	All wood energy
Finland	11.5	14.4
Sweden	8.0	9.9
Canada	3.0	3.5
New Zealand	2.0	2.0
United States	1.3	2.0

Source: International Energy Agency, 2003.

TABLE 11
Percentage of total roundwood production used for woodfuel, 1997

Region	Proportion of total roundwood production (%)
World	53
G8	14
Rest of the world	69
Developing countries	76
Africa	89
Asia	79
Europe	18
North America	15
South and Central America	59

Source: FAO, 2004.

by Africa (21 percent). Together, Asia, Africa and South and Central America account for 76 percent of global woodfuel production (Trossero, 2002).

In the future, the global production of woodfuel is expected to increase moderately, from 1 885 million cubic metres in 2000 to 1 921 million in 2010 and 1 954 million in 2020 (Broadhead, Bahdon and Whiteman, 2001). Fuelwood production is expected to increase in Africa and South America but decrease in Asia, while all three regions are expected to increase charcoal production. In addition, the use of black liquor for energy is likely to increase in countries where the pulp and paper industry is expanding.

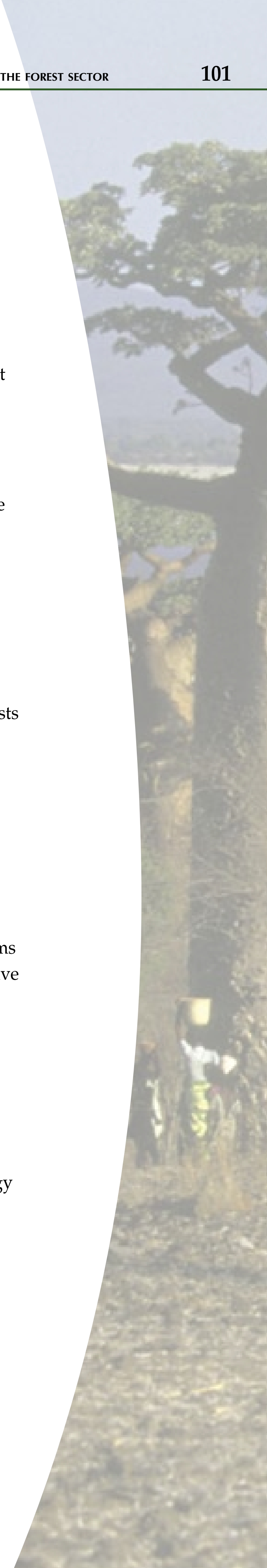
ECONOMIC VALUE OF WOOD ENERGY PRODUCTION

Wood energy contributes directly to national economies as a source of energy supply. However, because a large proportion of wood energy is not sold in the market, valuing this contribution is quite difficult. In addition, the social and environmental impacts of wood energy production and consumption are indirect effects – or externalities – of wood energy use. These externalities can be positive or negative and are also very difficult to value.

The contribution of any activity to the economy (e.g. to the GDP) is measured as the value added produced by that sector. This in turn is calculated by subtracting the costs of goods and services purchased from other sectors and used for production (e.g. fuel, tools and machinery) from the total value of output in the sector (i.e. quantity produced multiplied by price). The production of woodfuel involves few purchases from other sectors. This is particularly true in developing countries, where the main input used to produce woodfuel is labour (which is not counted as a cost in the calculation of value added). Thus, the total value of woodfuel production gives a reasonable approximation of the value added in the sector.

Currently, woodfuel prices range from around US$5 to $25 per cubic metre in developed countries and US$1 to $10 per cubic metre in developing countries (Broadhead, Bahdon and Whiteman, 2001). However, in developing countries, a large proportion of woodfuel is produced by individuals for their own consumption rather than for sale. In such cases, there are several ways of valuing production that is not traded in the market. One is to calculate the replacement cost of this production (i.e. the cost of replacing the production for personal use by the purchase of woodfuel or other types of energy), but this is likely to lead to an overestimate of the value of production. Alternatively, the value of production can be calculated as the cost of the time taken to collect woodfuel (as the value must be at least equal to this cost or collection would not take place), but this would probably lead to an underestimate of the value of production.

Taking into account these uncertainties, the market price of woodfuel can be used as a rough estimate of the value of woodfuel production. Therefore, with total production of around 1 885 million cubic metres (and assuming 75 percent in developing countries and 25 percent in developed countries), the total value of global woodfuel production could be in the range of



US$4 billion to $26 billion per year. These figures amount to about 0.01 to 0.06 percent of global GDP. Other types of wood energy (e.g. black liquor) are not included here, so these figures are an underestimate. However, they indicate that the direct contribution of wood energy to national economies is probably quite small.

Positive and negative externalities

The main positive externalities of wood energy are the effect on carbon balances of substituting wood energy for fossil fuels and the employment generated by wood energy production. The main negative externality is the environmental cost of woodfuel harvesting in terms of forest loss and degradation.

With the methodology currently used for carbon accounting, losses of biomass carbon are counted as part of changes in the stock of forest biomass. Thus, to avoid double counting, the use of wood energy is not counted as an activity that leads to CO_2 emissions even though it is one.

The potential for wood energy to lead to real changes in carbon balances depends on the source of woodfuel. If woodfuel is produced from sustainably managed forests where the wood harvested is replaced by the increment of the remaining growing stock, then the substitution of wood energy for fossil fuels will result in a real reduction in the net carbon balance. Similarly, if residues from harvesting and wood industry are used for energy production rather than left for waste, this would also have a positive net effect.

However, if woodfuel is produced on an unsustainable basis by clearing forests, the substitution of wood energy for fossil fuels will not have a positive effect on carbon balances and could even be worse than the use of fossil fuels. This is particularly true if wood energy is produced inefficiently. For example, inefficient kilns emit a great deal of CO_2 during the production of charcoal, resulting in very high emissions per unit of energy produced.

With respect to employment, woodfuel production is labour intensive and an important source of income and employment for rural households. Woodfuel production requires the highest amount of labour inputs per unit of energy produced: 100 to 170 person-days per terrajoule for fuelwood and 200 to 350 person-days per terrajoule for charcoal (Remedio, 2001). However, the benefit of this employment generation depends on the value of the labour used for production (Luoga, Witkowski and Balkwill, 2000). For example, employment can be considered as a positive externality if rural unemployment is high, but perhaps not if there are alternative uses for this labour. In addition, policy-makers should be aware that woodfuel projects and programmes may not always be the best way to increase rural income and employment.

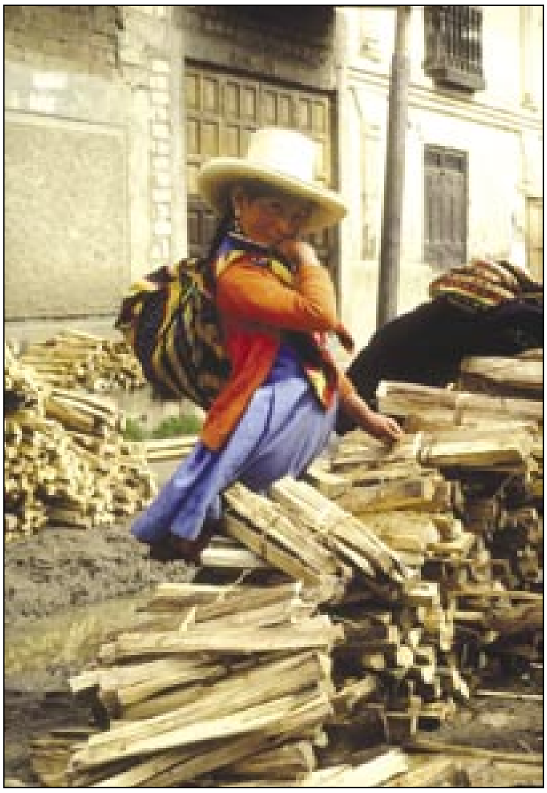
As with the impact on carbon balances, the environmental costs of wood energy use also depend on the source of woodfuel. Again, forests that are sustainably managed for woodfuel production are likely to lead to some positive externalities in terms of their environmental impact, while unsustainable harvesting for woodfuel production is likely to lead to environmental costs.

To summarize, the indirect effects of wood energy production and consumption are complex and not well known. However, it seems likely that on balance there may be some positive externalities from the use of wood energy in developed countries and negative externalities in many developing countries.

ECONOMICS OF WOOD ENERGY PRODUCTION AND CONSUMPTION IN DEVELOPING COUNTRIES

In developing countries, the use of wood energy is divided as follows: fuelwood, 90 percent; black liquor, 6 percent; and charcoal, 4 percent. Households (particularly rural households) are its main consumers, with industry and the service sector consuming far less.

The use of wood energy is determined by a number of factors, including price, income, availability of other types of energy and resource availability. In general, most consumers in developing countries use wood



Many rural households in developing countries only produce enough woodfuel to meet their own needs; some, however, are able to enter the market as sellers of woodfuel

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energy because their choice of energy supply is restricted by income and the availability of other types of energy.

Households that use wood energy can be divided into four types:

- households that only produce woodfuel for their own needs;
- households that produce and sell woodfuel;
- households that produce and purchase woodfuel;
- households that only purchase woodfuel.

Most rural households fall into the first and second groups, while most urban households fall into the third and fourth groups.

The price of woodfuel has a greater effect on consumption for the last three groups in the above list. For example, households that only purchase woodfuel are likely to respond to price changes by altering total energy consumption or switching to other types of energy. Price changes are likely to influence total production for the second group or total consumption for the third group. The effect of price changes on how much these groups produce for themselves will depend on the value of the labour they expend to produce woodfuel. For example, if prices rise, households in the third group are likely to produce more of their own woodfuel. In most cases, households in the first group do not participate in the market for reasons such as location (i.e. remoteness) and the low value of their own labour. However, if woodfuel prices change significantly, households in this group could enter the market either as buyers or sellers of woodfuel.

With respect to income, some researchers have found that the share of woodfuel in household energy use declines as per capita income increases (Sathaye and Tyler, 1991; Leach, 1988; Broadhead, Bahdon and Whiteman, 2001). On the other hand, Leach *et al.* (1986) reported that woodfuel consumption increased when incomes increased in very poor rural households in Brazil, India, Pakistan and Sri Lanka. Some others have also reported a positive relationship between income and woodfuel consumption (Shaw, 1995; Zein-Elabdin, 1997). Thus, it is not always the case that low-income households first use woodfuel and then ultimately progress to other types of energy as incomes increase. High-income households may consider woodfuel an inferior good, but low-income households may not share this view. Consequently, in poor countries, the switch from woodfuel to other types of energy is likely to occur slowly.

Generally, the decision to switch depends on the prices, availability, reliability of supply and energy content of the alternatives. Another factor is the cost of changing equipment (e.g. stoves). However, in many rural areas, there is no option but to use woodfuel because of remoteness and the lack of infrastructure for delivering other types of energy.

Surprisingly, black liquor contributes a little more than charcoal to the TPES of developing countries, but this is the result of high use of black liquor in only a few countries where pulp and paper production is significant (e.g. Brazil, Chile, China, Colombia, Indonesia and South Africa). The availability of by-products from the forest processing industry and recycled wood and paper products is significant and could be used to increase wood energy production, but this will depend on the profitability of using these materials for energy production compared with the profitability of alternative uses (e.g. as inputs for wood panel and paper manufacturing).

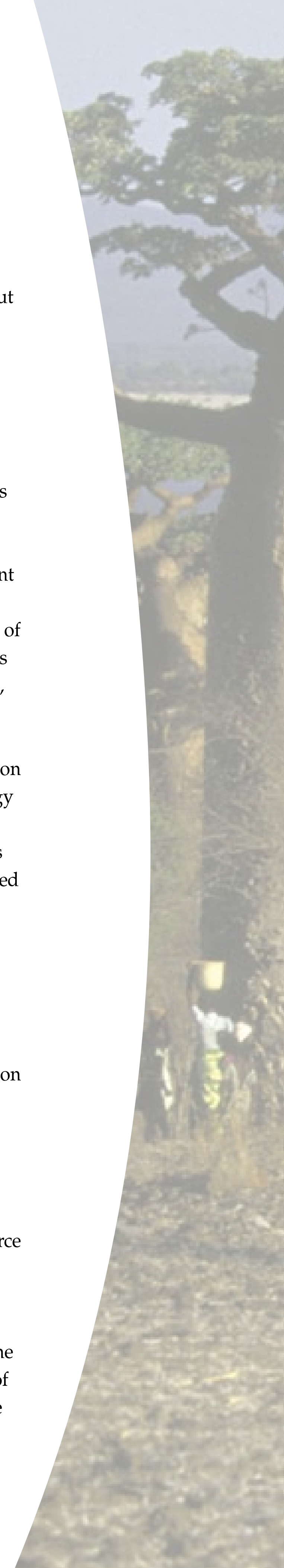
Other social and environmental factors that affect household woodfuel consumption include climate (e.g. altitude, length of winter and rainy seasons), access to markets and forest resources, health and environmental effects of woodfuel use (e.g. smoke) and cultural variables. For example, the failure of fuelwood and charcoal substitution programmes in many countries is attributed to the resistance of consumers to change cooking habits (e.g. to replace wood and charcoal stoves with alternative technologies). These other factors can be important and should be considered in wood energy policies and programmes.

ECONOMICS OF WOOD ENERGY PRODUCTION AND CONSUMPTION IN DEVELOPED COUNTRIES

With few exceptions, black liquor is the main type of wood energy used in developed countries. In 2001, black liquor accounted for 0.9 percent of TPES in G8 countries, compared with a total of 1.4 percent for all wood energy (Figure 12 and Table 10). In the countries of OECD, the contribution of all biomass energy to TPES is about 3.5 percent; biomass energy from agriculture and forestry accounts for about 86 percent of this (Radetzki, 1997).

Government efforts to boost the production of renewable energy include attempts by the EU to increase the share of renewable energy to 12 percent of all energy consumption and 22 percent of electricity consumption by 2010. In the EU plan, the expected growth in biomass energy production is second highest (after wind power), with an expected increase from 55 million to 135 million tonnes of oil equivalent (Harmelink *et al.*, 2004). Most developed countries treat biomass as an important source of renewable energy and have supporting policies in place (Table 12). In addition to governments, many other organizations also promote renewable energy. However, despite such initiatives, concerns remain about the production costs and financial viability of renewable energy production.

The cost of wood energy production depends on the source of wood used. In general, recovered wood and paper products and wood residues from the forest processing industry are likely to be the least costly sources of supply because they are concentrated in urban areas and can benefit from economies of scale in production. Harvesting residues and the forest plantations specifically managed for wood energy production are likely to be more expensive sources of supply. Consequently, wood energy systems in developed countries have tended to focus on using wood residues. However, there is an opportunity cost of using these materials for wood energy, as they are also an important source of supply for the forest industry. Thus, there are concerns about the impact that subsidizing wood energy will have on the forest industry. Promoting wood energy will be beneficial for the forestry sector as a whole, but the distribution of the costs and benefits of such policies across the sector needs to be evaluated carefully.



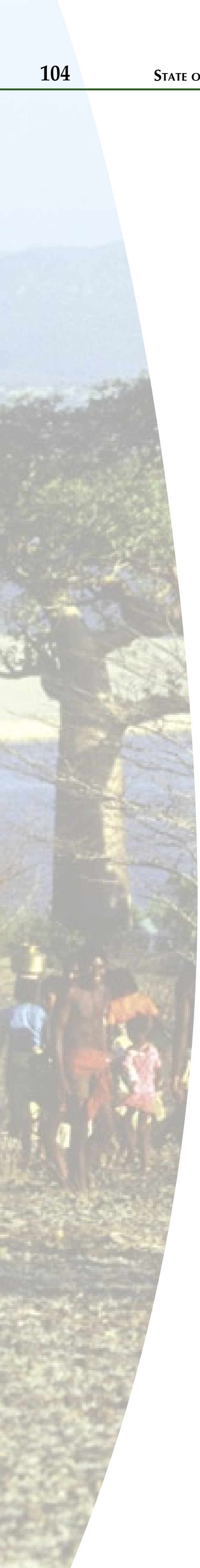


TABLE 12
Instruments used in OECD countries to promote renewable energy

	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Japan	Luxembourg	Netherlands	Norway	Portugal	Spain	Sweden	UK	USA
Research and development	■	■	■			■		■	■	■	■	■				■		■
Tax incentives		■	■	■	■	■	■		■	■	■	■		■		■		■
Subsidized loans	■	■			■	■	■	■		■	■	■		■	■			
Capital subsidies	■	■	■			■	■	■	■			■		■	■	■		
Feed-in tariffs	■	■	■		■	■	■		■		■	■		■	■	■		
Energy taxes	■											■						
Market liberalization					■		■						■			■		■
Information campaigns	■	■		■				■		■	■	■					■	■
Training				■			■	■				■	■					
Standardization			■		■		■		■	■		■	■					
Certification					■		■					■						

Source: Short and Keegan, 2002.

Green pricing programmes for renewable energy

In 2002, 90 green pricing programmes were offered to about 26 million consumers in 32 states in the United States. Almost 274 000 consumers participated in these programmes. The premiums for renewable energy ranged from US$0.007 to US$0.176 per kilowatt-hour, and consumers paid an average of US$4.43 per month for green power.

At the end of 2002, utility companies had installed nearly 290 megawatts of renewable energy capacity and had plans to install another 140 megawatts. Biomass energy production accounted for the second largest share of capacity, with 15 percent of installed capacity and 17 percent of planned capacity. About 25 percent of utility companies produced their own renewable energy, 46 percent purchased all of their supplies from other power generators or purchased renewable energy certificates, and the remaining companies used a combination of these approaches.

Source: Bird, Swezey and Aabakken, 2004.

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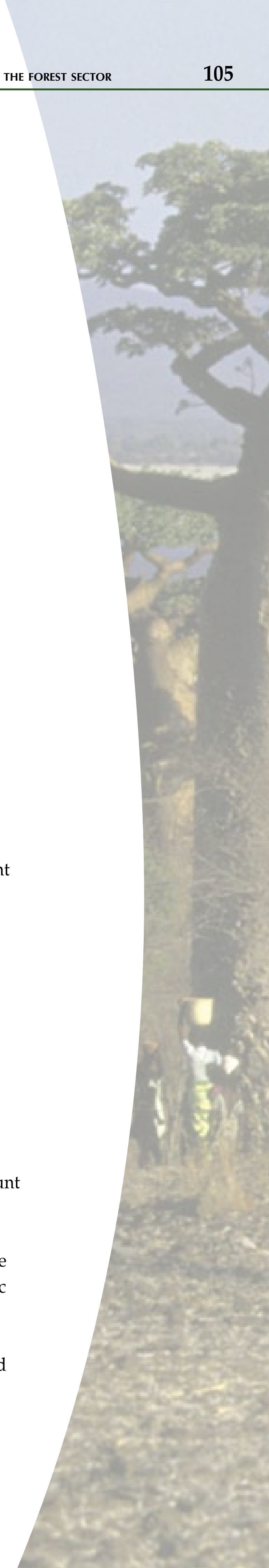
More fuel-efficient stoves improve the welfare and living conditions of people living in remote communities



Other factors that will affect the economic viability of wood energy are the demand for renewable energy and the non-wood costs of wood energy production. With respect to demand, energy pricing programmes in some developed countries have enabled consumers to choose renewable energy and pay slightly more for it (see Box on facing page). In addition to households, corporate consumers in the industrial and service sectors are starting to purchase renewable energy to improve their environmental image and as part of social corporate responsibility programmes. Thus, the prices for renewable energy may increase in the future, particularly if the market can be divided in this way.

In terms of production costs, the current cost of electricity production from biomass is about US$0.07 to $0.09 per kilowatt-hour, which is slightly higher than the cost of producing electricity from fossil fuels. However, in favourable situations, it can be reduced to as little as US$0.02 to $0.04 per kilowatt-hour (Ahmed, 1994). Furthermore, new and improved technologies, such as integrated biomass gasification plants, may soon produce electricity from biomass at about US$0.04 per kilowatt-hour (Elliott, 1993). More generally, Short and Keegan (2002) predict that the cost of biomass energy production will fall by 15 to 20 percent over the next 20 years, making it broadly comparable with the cost of energy from fossil fuels.

FUTURE STRATEGIES AND POLICIES

Over the next two decades, the importance of wood energy in developed countries is likely to increase as part of efforts to promote the use of renewable energy. This may also occur in developing countries, although the greatest changes can be expected from households switching from woodfuel to other types of energy. These transitions will require programmes and policies that take into account the complex economic forces that influence wood energy production and consumption. The following issues are put forward for consideration by policy-makers.

- At the international and national level, forestry and energy policies need to be complementary in order to achieve the benefits that wood energy can offer.
- Government subsidies for wood energy should continue in order to enable it to compete with other types of energy. However, subsidies need to take into account the impacts of greater wood energy use on other parts of the forestry sector.
- Policies and projects that encourage the use of wood energy should be based on holistic analysis of all the economic, social and environmental costs and benefits of wood energy. In situations where the use of wood energy results in significant benefits, this information should be disseminated widely.

- Attention should be paid to possible negative externalities of woodfuel use (such as nitrogen oxides and particulate emissions), which are largely unknown at the moment.
- Efforts should continue to improve the efficiency of wood energy production in developing countries. These could include not only the promotion of more efficient wood stoves but also the development of more modern production systems such as the use of wood for electricity production. Successful experiences with modern wood energy systems in some developed countries should be shared with developing countries through investment and technology transfer.
- Integrated operations that combine the use of wood for energy and the production of forest goods are likely to be more economically viable than systems that only focus on the production of wood energy. ◆

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