
4. The contribution of wood energy to future energy demand

The future of bioenergy and wood energy development is largely dependent on the effectiveness of policies and the consistency with which they are implemented. Abundant coal reserves are still available in areas of the world where economic and population growth rates are predicted to be highest. If high fossil fuel prices cease to exist as an incentive for biofuel development, only where policy is effectively implemented will demand increase. In many cases, policy support will therefore be necessary to encourage investment in bioenergy development – at least until price parity with fossil fuels is in sight. As such, export markets could become more important where domestic policies fail to encourage movement away from fossil fuels.

Widely differing systems of production and use of wood energy exist throughout the world, and there are likely to be a range of responses to the recent shifts in energy policy in various countries. Supply and demand of traditional biomass, liquid cellulosic biofuels, residues from the forest industry and other forms of wood energy will be affected differently by different factors across developed and developing countries.

Factors associated with climate change, energy efficiency and supply location will play a central role in wood energy production. In addition, an array of ecological, economic and social issues will come into play. In some areas and on some land types, trees may be more productive than agricultural crops and may not have as many negative environmental effects. Low labour availability could also favour forest over agricultural crops. Other factors may reduce demand on forests for energy production, for example, technological problems with liquid cellulosic biofuel production and transportation-related constraints. In general, the contribution of forestry to future energy production will be influenced by:

- the competitiveness of wood-based energy in achieving the objectives of recent energy related policies;
- the costs and benefits of wood-energy-related systems in social, economic and environmental terms;
- policies and institutions that provide the framework within which forestry acts.

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. Because of these many factors, it is difficult to make general comparisons between agricultural and forestry sourced bioenergy (Perley, 2008).

The development of economically competitive technology for the production of liquid cellulosic biofuels will cause a major shift in the importance of wood energy. At that point, forest products will compete directly with agriculture for a share in the biofuels market. Forest products will also become a source for transport fuel, and where energy consumption is significantly affected by policy measures (e.g. EU, United States), large markets will open up to forest-derived energy from developing countries around the world.

In many parts of the world, significant expansion of plantations for bioenergy may be hampered by impediments to investment such as conflicting land claims, insecure land tenure, risk of expropriation and ineffective governance. Social issues that commonly occur when natural vegetation is replaced with commercially managed crops may also arise as a result of changes in property and land-use rights.

Where agricultural crops are favoured over trees, the contribution of forestry may be confined to efficiency gains in current uses and increasing the use of wood residues from existing forestry operations. Under these circumstances, the availability of wood for bioenergy production is likely to be less controlled by energy markets than by trends in roundwood production, extent of forest resources and demands that compete for wood residues.

Although the price of oil is high, developing countries need to assess the risks associated with investments in bioenergy very carefully. Many investments in biofuels made in the 1980s collapsed shortly after oil prices returned to their original levels (IBDF, 1979; Tomaselli, 1982). But the situation is again changing as new elements such as global warming have become more relevant.

Investments in bioenergy often depend on subsidies and new technology developments. Developing countries have limited finances and many priorities, so a full assessment of the risks and the identification of ways of maximizing the benefits from investments in bioenergy are fundamental. The Clean Development Mechanism (CDM) of the Kyoto Protocol offers incentives for establishing energy plantations and financing sustainable biofuel use. The Kyoto Protocol also facilitates technology transfer to developing countries.

WOODFUEL SOURCES

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, in particular when used for heat and power generation. Besides being economically attractive, wood energy is a strategic option for increased energy security, particularly in countries that have large forest areas and that depend on energy imports.

Sources of wood for energy production may be derived from a range of existing production systems. Wood residues provide the greatest immediate opportunity for energy generation given their availability, relatively low-value and the proximity of production to existing forestry operations. 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 will contribute

energy logs as well as logs for other purposes as markets demand. Logged over forest areas and species not currently favoured by markets are additional potential sources of wood for energy.

Wood residues

Many countries have no clear perception of the amount of biomass that can be collected from ongoing forest operations, and have never assessed the full potential of wood residues for energy generation. Table 6 compares wood residue availability for natural forest in the Amazon region and fast-growing pine plantations for two typical industrial operations in Brazil. The information shows that only a small portion of the tree is converted into market products. In natural forests, between 80 and 90 percent of total residue volume could be used for energy generation. Most of this material consists of tree crowns and other rejected pieces that are left in the forest after harvesting operations.

In developing countries, excess wood residues at mill sites are often left unused and may create environmental problems by affecting water and air quality. Producing energy from these residues can solve both energy and waste disposal problems. Residue combustion technology includes simple steam machines for small-scale power production and steam turbines for larger power plants (ITTO, 2005).

Theoretical analyses of energy supply from wood residues in developing countries suggest that there is considerable potential for energy generation (Tomaselli, 2007). In countries such as Cameroon, wood residues generated at mills alone are estimated to be sufficient to supply the total national electricity demand. If all the residues from forest operations were used for electricity generation, the country would be able to produce five times its current demand.

Wood residues from mills could also produce a significant portion of the electricity consumed in Gabon, Nigeria, Malaysia and Brazil. The potential contribution of wood residues to total electricity consumption in India, Thailand, Colombia and Peru is relatively small by comparison.

Wood residues from mills represent only a small portion of the total residues available. The volume of wood residues left from harvesting operations in tropical forests is three to six times that generated at mills. Efficient harvesting and transport technology methods could be used to collect this material and deliver

TABLE 6

Wood residues from forest industry operations in Brazil (% of total wood harvested)

Operation	Natural forest		Plantations	
	Product	Residue	Product	Residue
Harvesting	30-40	60-70	80-90	10-20
Primary and secondary processing	10-20	10-20	30-40	40-50
Total		80-90		60-70

Sources: ITTO, 2005; STCP Data Bank (adapted)

it to power plants, in order to reduce costs, mitigate environmental impacts and produce power. Given that this is already done to a significant degree in most advanced industrialised countries, there is thought to be limited scope for increasing the energy use of residues there (Steierer *et al.*, 2007).

In many countries, the use of agricultural and forest residues could significantly reduce land requirements for biofuel production, thereby reducing the social and environmental impacts of energy crop plantations. In practice however, the wood that is reported as being available for industrial energy production often cannot be harvested economically. Furthermore, logging, agricultural expansion and other factors have reduced forest area all over the world. Wood residue supply can therefore be expected to decrease in coming years, despite high rates of plantation establishment.

Wood residues are necessary for maintaining soil and ecosystem health, and certain amounts should therefore remain on the ground. Logging residues are an important source of forest nutrients and help reduce the risk of soil erosion (UN-Energy, 2007). The potential impacts of increasing biomass recovery could include nutrient scarcity, loss of biodiversity and changes to ecosystem function.

Energy plantations

Energy crops are not a new innovation. Forest plantations dedicated to the production of wood for energy have existed in many countries for some time (NAS, 1980), though most of them are small, use poorly developed technology and generally focus on supplying fuelwood for local consumption.

In temperate zones, there are a number of fast growing tree species suitable for energy plantations, including *Acacia mangium*, *Gmelina arborea* and several *Eucalyptus*, *Salix* and *Populus* species (Perley, 2008). Tree growth rates are highly variable depending on management, species and location. In tropical countries, growth rates are highly dependent on water availability (Lugo, Brown, and Chapman, 1988). Soil fertility is also a factor. Short rotation forest crops demand higher nutrient status than other forests that occupy lands less in demand for agriculture.

Brazil is one of the few countries where the large-scale production of energy from wood has been explored for decades. Significant investments have been made in plantation forests, mostly of fast-growing *Eucalyptus* spp., dedicated to the production of wood for industrial charcoal to feed the steel industry. Brazil has also developed forest plantations to produce biomass for combustion and generation of heat and electricity for the food, beverage and other industries.

Clear and consistent policies, laws and best practice guidelines can help to balance the cultural, economic and environmental trade-offs caused by increased investment in forest plantations (FAO, 2007a). High-productivity plantations, efficient harvesting and good logistics are fundamental in producing biomass at costs that allow for competitively priced energy generation.

As a source for bioenergy, trees offer an advantage over many agricultural crops, which usually have to be harvested annually, increasing the risk of oversupply and

market volatility (Perley, 2008). The harvest of trees and other perennial crops can be advanced or delayed according to price fluctuations. Products include several different end-uses such as energy production, pulp or panel manufacture and even sawlog production.

Countries considering the establishment of energy plantations should begin by creating conditions for efficient production of bioenergy from plantations. This includes the development of appropriate genetic material for local conditions and advanced technology for silviculture, plantation management, harvesting, transportation and energy conversion.

Some developing countries would need to invest in technological research and development for several years in order to turn wood energy plantations into an attractive business. While risks can be mitigated by using suitable species and high quality genetic material, countries and investors need to be aware that they are dealing with the uncertainties of long-term investments. One major risk outside the control of countries and investors is the fluctuations in energy and wood prices over time.

Changes in energy prices may render woodfuel plantations for energy unviable, and consequently of no market value. This is less of a risk for countries with developed forest industries that can adapt the biomass to other uses. For example, wood pulp and reconstituted wood panels industries use the same raw materials, reducing the risk of investment in energy crop plantations. Investors need to consider whether forest planting and management for biomass is compatible with the forest industries currently operating in developing countries, especially the less developed ones.

Lesser used species and secondary forests

Species of wood that are not used by the timber industry represent another opportunity. A recent study analysed the possibility of combining the harvesting of traditional species for the timber industry with less-known or less-used species for energy production (ITTO, 2005). Such an approach to energy generation could lead to increased revenue and improve sustainable forest management.

Another opportunity to produce biomass for energy generation is the management of secondary forests. In tropical regions, extensive areas of secondary forests exist. This type of forest has large volumes of biomass that cannot be used by traditional wood-processing industries, which represent a potential source for energy generation. Application of the International Tropical Timber Organization guidelines for managing secondary forests can promote the sustainable development of these forests for wood energy production (ITTO, 2002).

Future wood supply

Given that the value of wood for fuel has been low in comparison with other end uses, the future supply of wood for bioenergy production is likely to come from existing forestry operations. This may change if technology becomes available for the economically competitive production of energy from cellulosic materials as outlined in Section 3.

Mabee and Saddler (2007) reviewed a number of regional and global outlook studies on forest fibre availability to determine the renewable global supply of forest biomass for wood energy production. They concluded that increased demand for wood energy in industrialized countries will have a significant impact on the amount of available excess forest biomass, taking between 10 and 25 percent of the estimated global surplus. The global availability of fibre may not, however, cover demand in some regions and increased demand from wood processing industries may also compete for supply.

The technologies and systems used for creating wood energy are of great importance in analysing the future availability of forest biomass for bioenergy purposes. Improvements in the efficiency of utilizing woodfuel could provide significant amounts of wood energy worldwide. By instituting a best practices approach to energy recovery (i.e. using CHP with flue gas recovery, or high-efficiency wood pellet stoves), the amount of energy available through woodfuel increases dramatically and the resource may be extended significantly.

Increases in forest-based bioenergy use may have an impact on traditional processing industries. In some industrialized countries, removals of wood from the forest for bioenergy applications already account for at least half of industrial roundwood production (Steierer *et al.*, 2007; FAO, 2007b). In others, the amount of wood used for bioenergy purposes is still small compared with industrial roundwood harvest. When residue recovery and postconsumer waste are factored in, however, wood use for energy exceeds industrial roundwood production in several industrialized countries. Possible impacts of wood demand for bioenergy production on forest product prices are detailed in Box 4.

EMISSIONS AND ECONOMICS OF BIOFUELS

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. Some options hold the potential for net emission reductions that exceed 100 percent – meaning that more carbon would be sequestered during the production process than would be emitted as carbon dioxide during its life cycle – if fertilizer inputs are minimized and biomass or other renewable sources are used for process energy (see Worldwatch Institute, 2007).

Studies suggest that use of bioethanol produced from maize represents only a slight improvement in fossil fuel use efficiency over direct use of petroleum, while bioethanol produced from wood can improve energy efficiency by up to four times (NRDC, 2006). Estimates put greenhouse gas emissions for biomass-based second-generation fuels at 75 to 85 percent below those of petroleum motor fuels, because of less-intensive farming and the assumption that the unfermentable portion of the plant is used as the processing fuel (Global Insight, 2007). Thus, 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

BOX 4 Forest product prices

In European countries, wood prices have been declining for both roundwood and pulpwood in real terms (UNECE, 2007; Hillring, 1997). The long-term global trend is more difficult to determine, owing to currency conversions, the impacts of national inflation rates, national tax regimes and data availability. Global estimates of the future forest products market predict that the real prices of industrial roundwood, sawnwood and wood-based panels will change little before 2010, with those of newsprint, printing and writing paper decreasing slightly (FAO, 1997; Trømborg, Buongiorno and Solberg, 2000). However, over the past few years, real prices of forest products have been rising around the world.

Recent studies noted that prices for softwood sawlogs increased in most regions of North America and Europe in 2005/2006 (UNECE/FAO, 2006; 2007). Higher transportation costs and incentives for bioenergy production were cited as major reasons for these increases. Pulpwood prices have also increased in these regions, again probably owing to increasing transportation costs but also an improved pulp market. Prices for sawnwood and pulpwood are predicted to continue to rise over the next few years (UNECE/FAO, 2006).

Given existing trends in wood prices, several observations can be made.

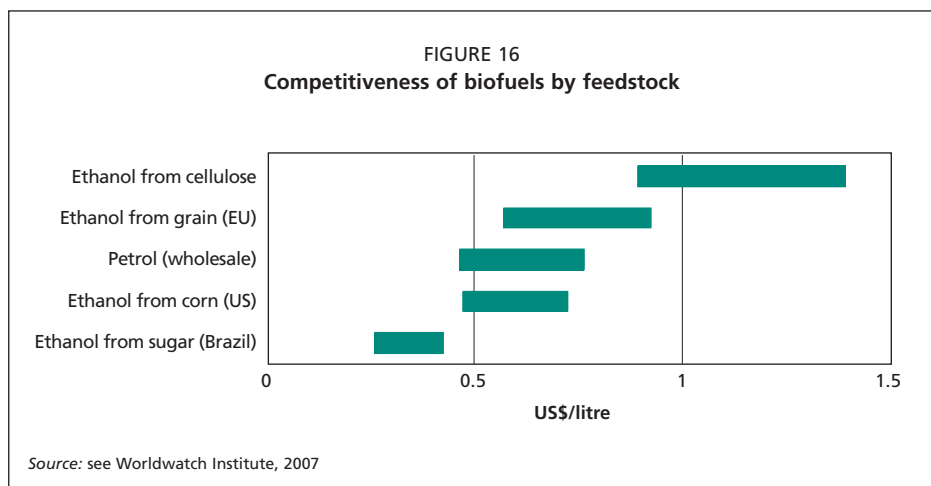
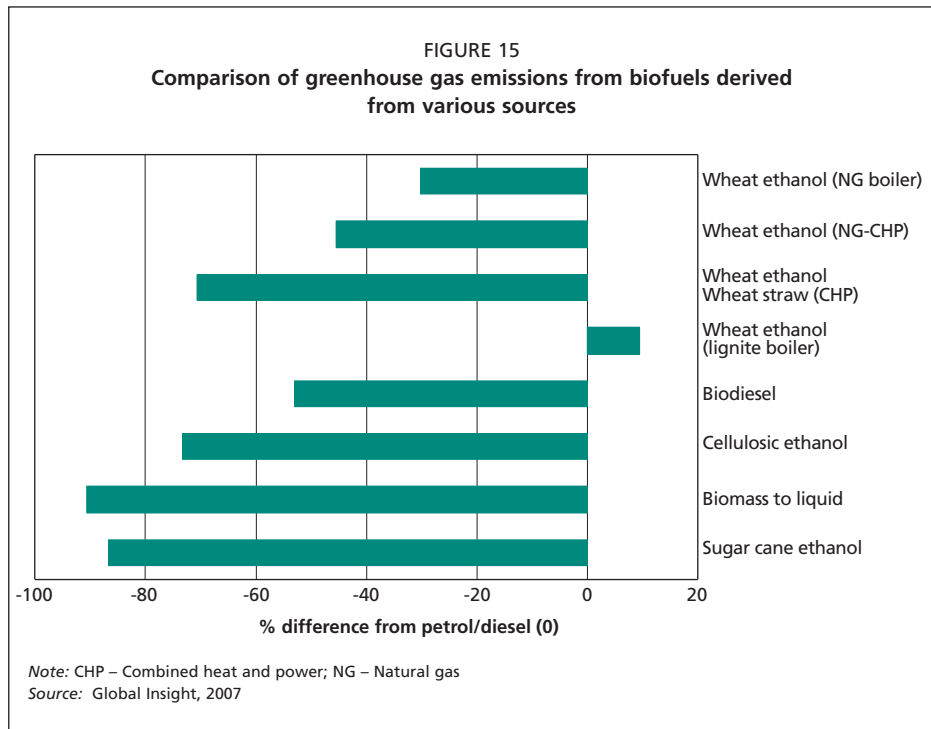
- Even with rising wood value, the forest industry is experiencing lower returns today than in previous years and this is likely to act as a barrier to reinvestment or to new companies entering the arena.
- The present price of wood, which is low compared with historical data, may act as an incentive to use wood in relatively low-value applications such as bioenergy.
- As bioenergy opportunities are explored, increased competition for wood fibre should support the recent trend towards higher wood prices. As wood prices rise, development of bioenergy opportunities may slow down over the medium- to long-term.
- Government policies can have a significant impact on wood prices. Subsidies for investments in renewable energy, tax incentives, and tariffs are all having an impact on wood prices, especially in industrialized countries.

At present, it is expected that high demand for wood-based biofuel feedstocks will result in price increases for forest products. Pulp mills and panel manufacturers are in most direct competition with bioenergy applications for wood supplies, and in the short-term it is likely that consumers will face higher prices for some products (UNECE/FAO, 2007).

efficiency and improved overall energy balance. This could result in incentives to expand forest plantations.

Compared to gasoline or diesel, greenhouse gas emissions are lowest for biomass to liquid processes (i.e. gasification/pyrolysis processes that can utilize the whole plant). Sugar cane is similarly placed and cellulosic ethanol reduces emissions by over 75 percent. Ethanol sourced from wheat returns poor emission reductions unless the wheat straw is also used in CHP processes (Figure 15).

Sugar cane is the most economically attractive agricultural feedstock for liquid biofuel, while maize and other cereal and oilseed crops from the Northern Hemisphere are less competitive under market conditions (Figure 16). While the present costs of producing ethanol from cellulose are higher than those from cereal feedstocks, the potential for reducing production costs in the future appears to be much greater for cellulosic ethanol. By 2030 parity with ethanol from sugar cane may be possible (IEA, 2006).



The development of an economically viable process for producing cellulosic liquid biofuels could lead to the widespread use of forest biomass in the transport sector. As most of the growth in demand for liquid biofuel is expected in developed countries, the scope for trade is the main factor affecting development plans in the majority of developing countries.

Feedstocks and processes that do not produce significant net energy gains are less likely to be supported by markets, although it is possible that other objectives may perpetuate their production (Wolf, 2007). It is unlikely that crops grown specifically for the production of cellulosic biofuels will be developed in significant quantities as technology gains and bioethanol prices are unlikely to favour production over alternative crops. Similarly, it is not expected that stand-alone second-generation bioethanol and biodiesel plants will be profitable in the coming decades (Global Insight, 2007). The competitiveness of different feedstocks is related to the net energy efficiency associated with production and processing of different crops (Box 5).

BOX 5

Energy efficiency and bioenergy production

Energy consumption in bioenergy production is important for two reasons. Firstly, to be sustainable, the amount of energy gained in growing and utilizing an energy crop must exceed that used in producing the crop. Secondly, the types of fuel used for the energy inputs and their greenhouse gas emissions must be taken into account where climate change goals are targeted through bioenergy use.

Energy use is dependent on a number of factors. Agriculture requires energy inputs at many different stages, including for powering farm machinery, irrigation and water management and transporting products. Large amounts of energy are also consumed in activities associated with agriculture, such as fertilizer and pesticide manufacturing and processing, and distribution of agricultural products. This is especially the case in modern high-input farming systems.

Agriculture in industrialized countries is generally much more energy intensive than in developing countries, although as they move to more advanced cultivation practices, energy inputs tend to increase. In many cases, energy inputs are likely to be from fossil fuels. For this reason, the production and use of bioenergy resources only marginally reduces carbon emissions in comparison with fossil fuel use.

The major advantage of forests and trees as a source of biomass is their lower energy inputs and their ability to grow on sites with lower fertility than those required for agriculture. There are, however, major constraints to capitalizing on these advantages including the timely emergence of second-generation technologies, the future supply of wood and the infrastructure necessary for economic viability (Perley, 2008).

