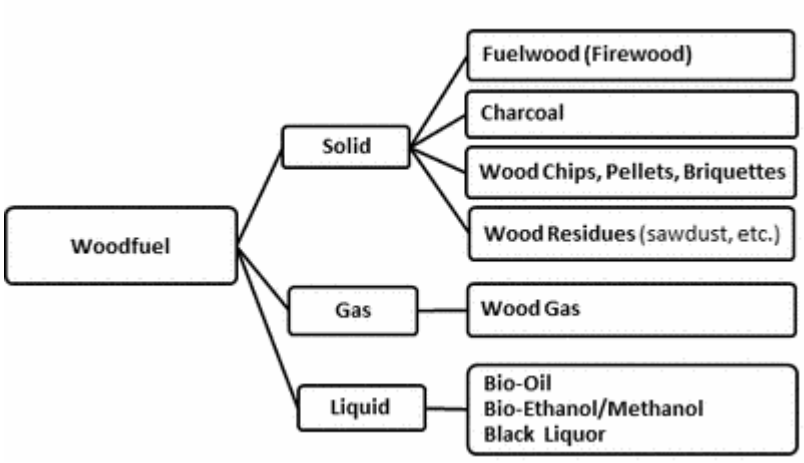
Wood Energy

Basic Knowledge

This module outlines the challenges and opportunities associated with the production and use of woodfuel and its socioeconomic and environmental impacts in developing countries. It discusses the role of value-chain approaches in addressing existing problems in the wood energy sector, and it briefly discusses the large-scale industrial use of woodfuel.

Wood energy is the energy generated from wood or wood-derived products – usually through combustion processes – and used for cooking, heating or electricity generation. The term "wood energy" is also used to refer to wood and wood-derived materials used for energy purposes ("woodfuel"), which may be in solid, liquid or gaseous form (Figure 1). Solid woodfuel includes fuelwood (also called firewood), charcoal and wood pellets (briquettes, chips) produced from wood or wood residues. Fuelwood comprises unprocessed woody biomass harvested from the stems, branches or other parts of trees, and it sometimes is also taken to include wood residues (such as sawdust and wood shavings) derived from timber harvesting or wood-processing industries used for energy production.

Figure 1. Common types of woodfuel



Wood is a basic energy resource for billions of people

One-third of households worldwide and two-thirds of those in Africa use wood as their main fuel for cooking, heating and boiling water (often essential for ensuring safe drinking water). Woodfuel provides more than half the national energy supply in 29 countries, mainly in sub-Saharan Africa. The total demand for woodfuel (particularly charcoal) is unlikely to decline in the short to medium term and may even increase as populations grow and become increasingly urban, and as wood is increasingly perceived as a green, renewable source of energy.

Despite its socioeconomic significance, wood is sometimes regarded as an inferior source of energy. For example, the traditional woodfuel* sector is often associated with unsustainable and often illegal production that leads to deforestation, forest degradation and, in some areas, woodfuel scarcity. Another problem associated with the traditional woodfuel sector is indoor air pollution due to the use of inefficient woodstoves, leading to health problems; moreover, fuelwood collection can impose a disproportionate work burden on women and children.

In many developing countries it may be unrealistic in the short to medium term to replace woodfuel with fossil fuels as the primary source of energy for cooking. Nor would this be an optimum solution given the availability, accessibility, affordability and potential sustainability of woodfuel compared with many other energy options. Rather, efforts are needed to address the problems associated with traditional woodfuel production and use through regulatory interventions, improved forest management practices, and technological advances. Combined, the following achievements would ensure a sustainable and viable wood energy sector in developing countries:

- the sustainable production of woodfuel in forests and trees outside forests;
- the efficient use and conversion of wood and wood waste to charcoal or other processed woodfuels;
- the clean and efficient use of woodfuel; and
- the full accounting of the socioeconomic and environmental benefits and costs of the wood energy sector – for example with regard to employment, gender equity, food security, human health and climate change.

The major challenges for the sustainable development of the wood energy sector include:

- the lack of sound data on production, transformation/conversion, trade and markets, and consumption;
- the lack of robust policies and regulations on, and effective governance of, wood energy plantations, woodfuel harvesting, and charcoal production and trade; and
- the heavy reliance of the poor on woodfuel for their basic energy needs and as an important means of employment for subsistence livelihoods.

In developing countries, woodfuel is increasingly used for power generation and for household heating using clean and efficient technologies, driven partly by concern about climate change and a desire to decrease greenhouse gas emissions caused by fossil fuels. For example, wood energy accounts for more than 10 percent of energy consumption in 13 European countries.

Emerging opportunities to improve the performance of the wood energy sector include:

- increasing awareness in the international community of the need to provide access to modern, sustainable sources of energy for all, including the poor;

- the active role of sustainable wood energy in climate-change mitigation;
- technological advances in the efficient industrial use of woodfuel in developed countries, which provides opportunities for technology innovation and transfer; and
- increased awareness of the need to address problems in the wood energy sector in a holistic and systematic way through value-chain approaches.

(*) *In general, traditional woodfuel production and use can be thought of as the collection or extraction of wood from natural or community forests for household cooking and heating or for small-scale productive use that generates income, as well as charcoal production using low-efficiency technologies to serve rural and urban market for household cooking or micro-enterprises.*

Wood energy contributes to SDGs:

Related modules

- Climate change adaptation and mitigation
- Gender in forestry
- Forest governance
- Forest inventory
- Forest law enforcement
- Forest management planning
- Forest policy
- Forest restoration
- Forests, food security and nutrition
- Reducing deforestation

In more depth

Understanding the energy use of woodfuel

Wood for energy use may come from various sources, such as natural forests, forest plantations, trees outside forests, wood residues from forest harvesting and wood-processing industries, and other waste wood. All wood comprises about 50 percent carbon, 44 percent oxygen and 6 percent hydrogen (when measured on an ash-free and moisture-free basis). The heating value of wood is greatly affected by its moisture content. “Green” (i.e. freshly cut) wood has a heating value of about 8.2 megajoules (MJ) per kilogram (kg), while air-dried wood (with a moisture content of 10–20 percent) has a heating value of about 16 MJ per kg (corresponding roughly to 0.382 kg oil equivalent, or 4.4 kWh). Oven-dried wood has a heating value of about 18 MJ per kg. In comparison, the energy required for household cooking (after accounting for the thermal efficiency of cooking stoves) in India has been estimated at about 7 MJ per household per day.

Wood may be used as fuel directly in its original form or after processing or transformation into charcoal, pellets, briquettes or chips, or into various products in liquid or gaseous forms. Such transformation is achieved through the use of devices ranging from the very simple (e.g. three-stone stoves and earth-pit charcoal kilns), to the more sophisticated (e.g. improved cookstoves), to the complex, such as large-scale wood-pellet plants, modern boilers, and advanced wood-fired electricity generation plants.

Wood energy has advantages and disadvantages. Woodfuel is often the most affordable and locally available fuel for cooking and heating, especially among low-income groups in developing countries. In general, the traditional household use of woodfuel declines as incomes rise and people switch to other fuels or electricity. On the other hand, the total demand for woodfuel at a national or regional level may increase as incomes rise due to population growth and – in many cases – to an initial switch in households from fuelwood to charcoal, coupled with growth in the industrial use of woodfuel.

Valuing the contribution of the wood energy sector

Woodfuel is often produced by the informal sector; in many countries, therefore, official statistical data are lacking. Nevertheless, the economic value of wood energy is considerable: for example, FAO has estimated that 195 million people in Africa are employed in the wood energy sector on a full-time or part-time basis – the equivalent of 45 million full-time jobs or roughly 4.6 percent of total employment in the region. The annual contribution of the charcoal sector alone to employment, rural livelihoods and the wider economy has been estimated at about US$650 million and US$450 million in the United Republic of Tanzania and Kenya, respectively. These estimates correspond roughly to 2.2 percent and 1.2 percent of the national gross domestic products (GDPs) of those two countries in 2009*.

The international community has recognized that wood energy has the potential to contribute to various Sustainable Development Goals (SDGs), particularly SDG7 (energy access), SDG13 (combat climate change), and SDG15 (sustainable forest management). Wood energy is also relevant to SDG3 (health and well-being) and SDG5 (gender equality) because the clean and efficient use of wood energy reduces deadly exposure to indoor air pollution and the time spent collecting wood and cooking, both of which are particularly important for women and children. The wood energy sector contributes to SDG8 (economic growth and employment); the modernization of the wood energy value chain would have considerable economic impacts and create many jobs, especially in rural areas.

Wood energy can play an important role in combating climate change. Until recently, the general view was that carbon emitted into the atmosphere due to the burning of woodfuel was carbon neutral because it was part of a closed loop in which tree regrowth recaptured the carbon emissions produced by burning. However, the net greenhouse gas emissions arising from wood energy production depend on various factors, such as time span, the availability and accessibility of wood feedstock, and the energy consumed in production, harvesting, transportation, processing and other steps in the value chain. The calculation of the net emissions associated with wood energy is complex, and determining the conditions under which it is carbon neutral remains a topic of intense study. Nevertheless, the net carbon emissions of wood energy are mostly considered to be lower than those associated with fossil fuels when the wood is produced sustainably.

(*) *World Bank data indicate that the GDPs of the United Republic of Tanzania and Kenya were US$28.57 billion and US$37.02 billion, respectively, in 2009.*

Value-chain approach to addressing wood energy sustainability

The traditional wood energy value chain starts with the growing of trees, followed by harvesting, drying and possible carbonization, bundling or packaging and transport to local or regional markets, and consumption by households and businesses. Market channels for urban supply may include direct sales by producers to consumers, and indirect chains that involve intermediaries or wholesalers and retailers who organize sales to consumers. In most developing countries, wood energy value chains are mostly domestic and follow domestic demand patterns (particularly – in the case of Africa and South Asia – those of nearby urban centres). The major actors involved in wood energy value chains are producers, transporters, traders (wholesalers and retailers), consumers and (traditional and official) authorities.

Enhancing the sustainability of woodfuel production

The global forest growing stock was estimated at 531 billion m^3 in 2015. The annual removal of wood worldwide was estimated at about 3.7 billion m^3, of which 1.87 billion m^3 was used as fuel. With the total forest carbon stock estimated at about 296 billion tonnes, the energy content of forest biomass corresponds to roughly 10 times the world's annual primary energy supply. Even though not all this woody biomass is accessible or economically viable for energy production, the potential of wood resources for helping meet global energy demand is significant. A recent study estimated that there were about 3 trillion trees on earth (compared with the widely accepted previous estimate of about 400 billion), which is about 422 trees per person. The tropical regions are home to around 43 percent of the world's trees.

The extraction of wood for energy is a driver of forest degradation, particularly in sub-Saharan Africa: a recent study estimated that from one-fourth to one-third of the woodfuel harvest worldwide was unsustainable, with large geographic variations. Approximately 275 million people live in woodfuel-depletion hotspots concentrated in South Asia and East Africa, where most demand is unsustainable.

The wood energy sector in many countries is characterized by the presence of numerous actors, informal practices, the unequal distribution of benefits, and a lack of incentives to produce woodfuel sustainably. Issues include a resource deficit due to extraction rates that exceed natural growth; a lack of woodfuel plantations; insecure tenure and access rights; the unequal distribution of benefits to producers; competition for the use of trees and land; a lack of awareness and knowledge of sustainable management practices; the low efficiency of charcoal production; and weak resource governance.

Potential interventions to increase the sustainability of wood energy production include improving forest management; the establishment of dedicated woodlots for energy production; and the efficient use of wood wastes from harvesting and processing industries. Wood production may be increased by incentives to improve the management of degraded forests; the adoption of agroforestry; and the reforestation of fallow or degraded land. Other measures include participatory approaches for resolving conflicts over land tenure, better planning and monitoring, and the improvement of tree harvesting techniques and regulations.

Improving the efficiency of woodfuel conversion and consumption

The efficiency with which wood is converted to charcoal is often well below its technical potential. In many African countries, for example, the prevailing wood-to-charcoal conversion efficiency is about 15 percent, which means that 100 kg of wood produces 15 kg of charcoal. Improving conversion efficiency to 25 percent – which would reduce the volume of wood required to produce 15 kg of charcoal by 40 percent – may not require a large upfront investment other than that required to improve the technical skills of charcoal producers. Given the increasing demand for charcoal, improving the efficiency of charcoal production is urgently required (see FAO, 1987 for technical information on efficient charcoal-making).

The inefficient combustion of woodfuel using traditional stoves results in significant indoor air pollution. Although advanced wood-burning stoves can obtain thermal efficiencies of more than 50 percent, three-stone fires with a thermal efficiency of less than 15 percent are still used widely. Learning the lessons of previous programmes, future programmes that introduce and disseminate improved cooking stoves must take into account the cooking practices and economic, social and cultural circumstances of target users. No matter how efficient or cheap the stove, uptake by households will be low if the stove is difficult to install and maintain or not easily adaptable to local preferences. On the other hand, households have tended to be most receptive when the dissemination process has taken full account of the capacities and needs of local stove producers and consumers.

Technological progress in the modern industrial use of woodfuel in developed countries may inspire innovations for more efficient conversion and productive uses, but the investment scale of some technologies and the cost of the products may be prohibitively high to be replicated in many less-developed countries, even though such stoves are clean and efficient. Thus, low-cost appropriate technologies that match local socioeconomic conditions should be explored further, such as improved charcoal kilns, the small-scale production of wood pellets, and efficient stoves for wood/charcoal briquettes for productive uses.

Improving governance in the woodfuel sector

Wood energy suffers from a lack of recognition in national planning, at least partly because it spans the energy, forestry, agriculture and rural development sectors but is not fully incorporated in any of these, and partly because of the complexity of dealing with a largely informal sector. Wood energy is also relevant to several other sectors, such as environmental protection, gender development, and transportation. There is often poor coordination between institutions in the various sectors affecting wood energy, and agencies tend to see little benefit in expending effort in the sector.

Many countries lack policies governing woodfuel production, trade and consumption. Even when such policies are in place, they are often vague, inconsistent, contradictory or conflicting. Moreover, the institutional capacity to enforce wood energy policies and regulations (where

they exist) is often weak and, as a consequence, illegal logging and trade may be widespread. Institutional weaknesses, coupled with unclear policy and legal frameworks, invite corruption, which is a major cause of a lack of regulation and enforcement in the wood energy sector, particularly with respect to charcoal production and trade.

Addressing the problems associated with wood energy production and consumption and improving governance in the sector requires political will. It also requires effective cross-sectoral coordination to balance the needs of stakeholders and to create a harmonized regulatory environment. An important step in building political will is recognition of the important role a sustainable wood energy sector can play in national energy and food security, environmental conservation, rural livelihoods, health, gender development and job creation.

The provision of adequate data and information on the wood energy value chain is important for the formulation of sound policies and regulations in the sector. To improve data availability and reliability, regular surveys should be carried out on woodfuel production and supply, trade and transport, end-user consumption, and market demand, and how these are changing over time.

Gender & wood energy

In many countries, women and girls are primarily responsible for collecting fuel and cooking for their families. In India, for example, women gathering firewood, crop waste and cattle dung fulfil 92 percent of rural domestic energy needs. Many of the people who are involved in the woodfuel trade or who work in rural industries or commercial enterprises that use woodfuels are women. Although this means that gender aspects play an important role in wood energy, this is rarely reflected in wood energy planning and programming.

Generally, women are responsible for wood fuel collection by gathering from public sources or from private land, such as farmland and home gardens. Safe access to woodfuel is a direct benefit for their food security and overall health but — depending on the context — collecting woodfuel can be unsafe for the women involved. Efforts have been made to set up tree planting programmes aimed at increasing woodfuel supplies that are easier for women to access and, thus, can reduce gender-based violence.

Planting and taking care of the trees means extra work for which women may not have time. When women do plant trees, they are able to use it for household consumption, or sell it for cash, but depending on the cultural and family context, they may not be involved in deciding how to spend that cash. The choice of tree species is also a subject where gender plays a role, because men generally prefer trees that can be sold as timber, while women may prefer fast-growing species that provide them with fuelwood.

To reduce the wood energy gender-related disparities that exist some measure may be taken:

- ensuring safe access to wood energy through awareness raising of the issue and forming wood fuel collection groups or collection points;
- incorporating improved technology such as clean and efficient cook stoves to alleviate the burden on women;
- improving women's decision making power within forest management planning;
- including gender equality principles in energy policies, which can catalyse national development and play a vital role in realizing the Sustainable Development Goals (SDGs).

Modern use of wood energy

Liquid and gaseous fuels derived from woody biomass are yet to be commercialized for industrial use. Solid woodfuel in the form of wood pellets and wood chips, on the other hand, are used at a large scale for power generation and district heating in many industrialized countries, mainly in Europe.

Global wood-pellet production was estimated at around 24 million tonnes in 2014, of which more than 60 percent was produced in Europe and about 26 percent was produced in North America. The top wood-pellet-producing countries are (in descending order, by volume) the United States of America, Germany, Canada and Sweden. The cost breakdown of wood-pellet production and energy consumption along the value chain varies significantly depending on various factors, such as the source of wood, the harvesting system employed, the scale of wood-pellet production, and the transportation distance. In one case study, the cost breakdown was as follows: feedstock supply, 40 percent; pellet production, 30 percent; and transportation, 30 percent. The energy consumed along such a value chain may account for about one-fourth of the total energy content of the wood pellets.

European industrial consumers of wood pellets generally receive certain subsidies because their projects are intended to support compliance with government-sponsored renewable energy and climate-change goals and mandates. The major operators of solid biomass power plants in Europe are the Drax Group (United Kingdom of Great Britain and Northern Ireland), UPM/Pohjolan Volma (Finland), E.ON (Germany), Fortum (Finland) and Vattenfall (Sweden). Wood pellets consumed in the non-industrial sectors in industrialized countries constitute a more-or-less established, affordable heating option that does not necessarily receive government subsidies.

The major concerns about the large-scale modern use of wood energy include production sustainability in the context of land-use change and the impact on food security; the net greenhouse gas emissions of the wood energy system (i.e. biomass production, harvesting, processing, transport and use); the justification for subsidies for wood energy in power generation and district heating; and the impacts of large-scale commercial logging for industrial use on the environmental services of forests and possible biodiversity losses due to habitat change. The large-scale industrial use of wood energy has multiple socioeconomic and environmental impacts at the landscape and even larger scales and its sustainability warrants careful consideration.

Improving the performance of the wood energy sector

The wood energy sector faces a range of socioeconomic, technological, market, financial, institutional, policy, regulatory and governance barriers that are deeply rooted and which impose significant constraints. A systematic approach – with interventions along the entire value chain – is required to tackle the problems in the sector, which may involve (among other things):

Recognizing the value and importance of the wood energy sector in the provision of energy services, an assessment of the current status and future trends in wood energy production and consumption, and the development of cross-sectoral enabling policies and measures. A report by the World Bank provides a good example of the importance of awareness-building and sectoral reform.

Developing tools to support policy formulation and decision-making processes, particularly in resource assessment and supply–demand analysis and planning, and strengthening the institutional framework and cross-sectoral coordination to create an enabling environment for investment and innovation in the wood energy sector.

Enhancing technical capacity to improve the sustainability of wood energy production, the effective use of wood waste, the efficiency of charcoal-making, and the cleaner use of wood energy in the household sector.

Avoiding or minimizing negative social and environmental impacts associated with scaling up wood energy production to meet demand in industrialized countries.

Inviting relevant regional and international organizations to foster dialogue and the exchange of information and experiences on good practices in resource governance for a sustainable wood energy sector.

Further Learning

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Credits

This module was developed with the kind collaboration of the following people and/or institutions:

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This module was revised in 2017 to strengthen gender considerations.

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