Sources and Uses of Wood for Energy

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Abstract

As of August 2007, about 2.1% (2.1 quadrillion Btu, or quad; 2.2 EJ) of energy used in the United States came from wood. This could potentially increase to 10 quad (l0.6 EJ), or about 10.0% of U.S. energy use. This amount of wood is readily available. Wood use is competitive with other fuels in some applications now and will become more competitive as fossil fuel prices continue to increase at a more rapid rate and environmental pollution from burning fossil fuels receives more attention. Development of wood energy is needed to ensure our energy security.

The amount of energy we now produce from wood is similar to what we obtain from hydropower and nuclear power. The major wood energy users are the forest products industry and homeowners. We could increase use significantly, without depleting our timber resource, by using material not now used, such as logging residues, manufacturing residues, land-clearing residues, urban wood residues, and wood from insect-, disease- , and fire-killed trees. Nationwide, volume of annual wood growth exceeds the volume that is cut.

Although gradual or sharp increases in fossil fuel prices will increase wood energy use, we could obtain many benefits of wood energy use sooner if we continue to improve technology for producing and using wood-based fuels. With a modest research and development effort, use could increase from the current 2.1 quad (2.2 EJ) to 4.0 quad (4.2 EJ) by 2011. A strong commitment could lead to production of 6.0 quad (6.3 EJ) by 2016, and a sustainable 10 quad (10.6 EJ) by 2030. To more fully utilize wood, we must overcome obstacles, including high cost of harvesting and collecting wood, lack of infrastructure for marketing wood fuel products, emphasis on nonwood fuels in research and subsidy programs, and failure to give due credit to environmental, national security, and economic benefits in use of wood fuels.

Introduction

In 2006, wood was the sixth largest supplier of energy in the United States (behind oil, coal, natural gas, nuclear power, and hydropower) and the second largest renewable energy source after hydropower. Most wood is consumed in the residential and industrial sectors of the economy. Commercial, institutional, and transportation sectors use small amounts. For transportation fuel, a paper mill in Bellingham, Washington, has a capacity for manufacturing 7 million gallons (26.5 million liters) of ethanol per year as a byproduct from plant waste. In the residential sector, about 0.39 quad (0.41 EJ) of biomass, predominantly wood, was consumed in 2006. This represented 1.85% of total residential energy consumed. Residential fuelwood costs vary widely depending on location, land ownership, and amount of personal labor expended in

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harvesting and handling. However, for equivalent heating value, wood at $60 per ovendry ton ($66.14 per ovendry tonne) is about 29% of the cost of natural gas at $12.53 per 1000 ft^3 ($0.443/m^3), based on cost per unit of energy. In the industrial sector, 1.469 quad (1.550 EJ) of wood was consumed in 2006, or about 4.6% of total industrial energy consumed (USDOE 2007).

The pulp and paper industry accounts for much of the wood energy use in the United States, and it is increasingly using more in all categories, including hogged wood, bark, and waste processing liquor. Self-generated and residue sources of energy accounted for 55.4% of total consumption of the pulp and paper industry during calendar year 1999 (EPA 2002). In contrast to increasing industrial use of wood for energy, residential use of wood fuel dropped. Figure 1 compares wood and other fuel use in 2006. Figure 2 shows U.S. Department of Energy estimates of trends in use of wood for energy.

Sources of Wood Fuel

Wood used for energy is derived largely from materials that are not suitable for other products. However, in some parts of the country, unsplit roundwood for fuel sells at about the same price as pulpwood. Even though pulpwood material may be used for fuel in some areas, there is still much wood residue in our forests.

Of the estimated 18 billion cubic feet (509 million cubic meters) of roundwood timber harvested in the United States in 1986, 3.53 billion cubic feet (100 million cubic meters), the equivalent 1.0 quad (1.1 EJ), was used for fuelwood (USDA Forest Service 2007). This declined to 1.52 billion cubic feet (43 million cubic meters) in 2002 but is projected to increase to 3.46 billion cubic feet (98 million cubic meters) by 2050 because of increasing non-wood fuel prices for these sectors. In 1986, only 27% came from material classified as growing stock, that is, main stem portions of live sawtimber trees and poletimber trees, meeting specified standards of quality or vigor. The growing-stock portion of roundwood used for fuel is assumed to remain relatively constant over the projection period at 27%.

Roundwood is increasingly harvested for energy by whole-tree chipping. This method is particularly appropriate for supplying wood to 10- to 50-MW power plants. Wood-burning electric power plants were operating in 2002 or under construction could generate 7,540 MW and consume 75 million green tons (68 million green tonnes) or 37.5 million ovendry tons (34.2 million ovendry tonnes) of wood chips per year. Electric power production has increased from 0.13 quad (0.14 EJ) in 1990 to 0.19 quad (0.20 EJ) in 2006 (USDOE 2007). In 1984, 14 whole-tree chippers were in operation in the forests of Georgia, producing 972,000 tons (882,000 tonnes) of chips for energy. New England and California are leaders in chipping in the woods for energy today.

Wood is also consumed for fuel at manufacturing plants, after it has been removed from the forest for other purposes. Most of this is in the form of residues from primary wood products manufacturing. Black liquor, or waste processing liquor from kraft pulping operations, produced 0.9 quad (0.95 EJ) of energy in 2003. Another 0.75 quad (0.79 EJ) was obtained from wood in the form of sawdust, slabs, edgings, chips, bark, and veneer clippings at lumber and plywood manufacturing plants in that year.

In addition to the wood consumed in industrial plants and homes, comparatively small amounts are used in commercial and institutional buildings.

Continued Availability

In considering expanded use of wood for energy, whether we will have enough wood to supply our needs for wood and fiber products as well as for energy is a valid concern. Numerous examples of severe problems from overcutting forests have occurred in the past, and in many countries these problems are resurfacing today. However, much of our fuelwood comes from material that otherwise would not be used. Unremoved forest residue can cause difficulties in fire, insect, and disease protection or occupy space that might be better used by young, vigorous trees. Nonetheless, we must be aware of environmental problems that would be exacerbated in harvesting more wood for energy.

More research on the relationship between wood removal and nutrient balance for different situations is necessary. If more wood is removed from the land instead of being left to decay, fewer nutrients will be recycled back to the soil. How much nutrient material may be removed safely before replenishment is necessary is not certain. Undoubtedly this will vary with soil types, stand growth characteristics, and climatic conditions.

Although better information on nutrient cycling is needed, we should not be hard pressed to supply energy from wood in the United States in the near term. Table 1 shows potentially available sources of wood for energy and other uses. The numbers in the table add to 366 million dry tons (332 million tonnes), but because of rounding they are short of the 368 million dry tons (334 million tonnes) that the report says are potentially available (Perlack et al. 2005). We are obtaining about 2.1% of our energy from wood now. The 368 million dry tons represents another 6.3 quad, or another 6.3%, of our energy consumption. We also have much “non-commercial” timber that we have accumulated over the years in inventory. Therefore, the potential is that if we used available regenerating wood plus some of the existing inventory, we could get around 10% of our total energy from wood. To do this we would need to conserve energy as well.

We could use much of the potentially available residue wood and some inventory for energy. Another proposed goal expressed by Forest Service Chief Gail Kimbell is replacing as much as 15% of our current gasoline consumption with ethanol from wood.

In his 2006 State of the Union address, the President announced an “Advanced Energy Initiative” that included a national goal of replacing more than 75% of U.S. oil imports from the Middle East by 2025. To help attain this goal, the U.S. Department of Energy established the “Biofuels Initiative,” which includes goals to make cellulosic ethanol cost competitive with gasoline by 2012 and to replace 30% of current levels of gasoline consumption with biofuels by 2030. In 2007, the President initiated the “20 in 10” effort to reduce U.S. gasoline use by 20% by 2017.

Need for Expanded Use of Wood for Energy

Consumption of an estimated 2.1 quad (2.2 EJ) of energy from wood in 2006 amounts to 2.1% of our total consumption including wood. This is somewhat less than the 2.9% from hydropower and 8.2 % from nuclear power. Aggregate use has been relatively constant since 2001 and short of the recent high of 2.848 quad (2.9 EJ) in 1985. Wood biomass now accounts for about 3% of

U.S. energy production. A number of government initiatives could increase use of wood energy, including the federal Biofuels Initiative and state-level renewable portfolio standards (RPS). A Mandatory Fuels Standard, if enacted, could also have an effect. Since about 2000, wood biomass use for energy is estimated to be relatively constant in residential, commercial, and industrial uses, but increasing from a relatively low level in producing electricity (USDOE 2007). Use of an additional 366 million ovendry tons (332 million ovendry tonnes) per year of wood for energy would supply 6.2 quad (6.6 EJ); if only half the residues are available economically in the short term, this amounts to an additional 3.1 quad (3.3 EJ).

Having a substitute fuel is important in case imports are cut off and fossil fuel supplies are depleted, causing prices to rise. The urgency for supplying alternative forms of energy is less during a period of low and decreasing oil prices. However, since July 2005 we have encountered increasing oil prices, and crises similar to those in 1973 and 1979 could occur.

Problems that could develop from a new oil crisis are indicated by the record of oil prices since 1975 (Figure 3). After the oil crises in 1973 and 1979, oil prices doubled. Prices gradually decreased from 1979 to 1986. The situation since has been unsettled, but imports increased significantly (Figure 4). Energy security is threatened by our dependence on foreign oil sources.

According to the Energy Information Administration, U.S. consumption of liquid fuels including fuels from petroleum-based sources and, increasingly, those derived from such nonpetroleum primary fuels as coal, biomass, and natural gas is projected to total 26.9 million barrels per day in 2030, an increase of 6.2 million barrels per day over the 2005 total.

Deterrents to Expanded Use

Whether increase in use of wood for energy is rapid or sluggish depends on some artificial and institutional deterrents as well as economics and environmental concerns. Some important deterrents to growth in use of wood for energy are (1) difficulties in harvesting and collecting forest wood, (2) lack of infrastructure for marketing wood products, (3) obsolete conversion technology, and (4) higher subsidy for nuclear energy output than for wood.

Wood harvested for energy or pulpwood is usually of smaller diameter than saw logs, the harvesting of smaller material is usually more expensive, and the delivered value is often less because it is not suited for manufacture of wood products such as lumber and plywood.

The energy industry is reluctant to build plants fired by a nontraditional fuel with a supply system that may not be reliable, and the forest products industry is reluctant to develop a supply infrastructure without long-term contracts from those who would use the wood as an energy source (UT 1986). Koning and Skog (1987) proposed farm or farm-like cooperatives as an alternative where larger quantities of wood fuel are used.

Residential wood heating has been inefficient and the source of much air pollution. But steps are being taken to ensure better controls for home heating applications. New controls may include catalytic converters, computer logic, airtight combustion chambers, and regulated supply of combustion air. It is also necessary to develop improved technology for industrial, institutional, and commercial installations where larger quantities of wood fuel are used.

In a study by the Rocky Mountain Institute (Heede and Lovins 1985), it was estimated that more than $50 billion was spent in energy subsidies by the Federal government in fiscal year 1984. But these subsidies were unevenly allocated. Renewable energy other than hydropower produced 1.7 million Btu (1.8 million kilojoule) per dollar of subsidy. Nuclear energy received 80 times as much subsidy per unit of energy and produced about 20,000 Btu (21,100 kJ) per dollar of subsidy.

Factors Favoring Expanded Use

Important conditions favoring expansion of wood use include (1) cost savings (2) reduction of forest fire hazard and mitigation of insect and disease risk, (3) reduced emissions of sulfur and oxides of nitrogen from boilers, (4) control of the greenhouse effect, and (5) national energy security.

Much press commentary has focused on the difficulty in finding landfill space for municipal solid waste. Much of this solid waste consists of paper, demolition waste, tree trimmings, and other forms of wood. If more of this material were used for fuel, need for landfills could be significantly reduced. Managing public and private forest harvesting operations poses a similar problem. Often brush from logging operations is concentrated and broadcast burned to prepare land for new tree growth. This consumes management funds and subjects the atmosphere to more particulate loading as well. However, in some locations the Forest Service avoids broadcast burning by offering cleanup credits for harvesting excess wood for energy. This means that wood is burned in boilers instead of being burned in the open, and emissions are reduced.

Another increasing concern in the United States and Canada is acid rain. One suspected reason for increased acidity in precipitation, although by no means proven, is increased emission of various oxides of sulfur and nitrogen to the atmosphere. Burning wood usually produces less of these emissions than does burning high-sulfur coal and sulfur-containing petroleum.

Burning fossil fuels seems to be increasing atmospheric carbon dioxide and contributing to the “greenhouse effect.” This is not the case with wood burning as long as new timber grows to consume carbon dioxide given off by previous generations of wood burning. Only if forests are cleared for other types of land use, such as highways, dwellings, and cattle ranches and the removed wood is burned will there be an addition to atmospheric carbon dioxide content. Thus, normal woodburning will not add carbon dioxide to the atmosphere permanently, but burning of fossil fuels will.

Energy security is another factor favoring wood use. The Energy Security Act of 1980 contained several specific provisions to support making ethanol from wood (Gavett et al. 1986). It also contained general recommendations to (1) allow market forces to determine the types and quantities of wood produced and consumed for fuel and (2) support selected longer term wood development activities. A goal for liquid fuel production was determined to be 8.4 billion gallons (31.8 billion liters) of fuel alcohol (ethanol and methanol) from wood. A goal for nonalcohol wood was not set, but as directed by the Congressional Conference Report (Senate Rept. 96-824, House Rept. 96-1104) that accompanied the Energy Security Act, the U.S. Department of Agriculture and U.S. Department of Energy forecasted that 4 quad (4.2 EJ) of nonalcohol wood could be in use annually by 1990 (USDA and USDOE 1983). This did not occur, but with current support programs the potential for the near future is better. Most of this energy would be provided by the direct combustion of wood, although the emphasis of current subsidies and incentives is for making ethanol for transportation fuel.

Future Use of Wood for Energy

The Energy Security Act of 1980 called for periodic progress reports. The first report contained a comprehensive wood production and use plan from 1983 to 1990, but the report for 1987 neglected wood (USDOE 1987). Referring to world wood use, it states that "Burning wood in lumber and paper industries and simple burning of wood and other biomass in scattered locations are mature technologies that are not expected to contribute more than 7.5 million barrels per day of oil equivalent after 1990." This is equivalent to about 16 quad (16.9 EJ) per year and greatly underestimated the potential. Figure 5 shows historic and projected apparent roundwood consumption in the United States from 1952 to 2050.

EPACT, the Energy Policy Act of 2005, provides authorization for grants to owners or operators of facilities that use biomass as a raw material to produce electricity, sensible heat, or transportation fuels, and for research opportunities to improve the use of or add value to biomass. The act gives special emphasis to production of ethanol from lignocellulosic biomass. This includes loan guarantee programs for construction of facilities. There are also targets for production of ethanol from biomass by 2012 and beyond.

A study at the Agricultural Economics Department at the University of Tennessee in 2006 determined that a goal for production of 25% of the U.S. total energy needs from America's farms, forests and ranches by 2025 was feasible (English et al. 2006).

A U.S. Department of Energy imitative would replace 30% of gasoline with ethanol or other biofuels by 2030.

Conclusion

We have large supplies of unused wood material that would allow an increased commitment to developing wood energy. Such a commitment would

- reduce the potential damage of a cutoff of oil imports,
- reduce emissions of sulfur from boilers,
- help control the greenhouse effect, and
- reduce hazards to forests by cleaning up harvest sites.

An increased commitment should address

- the need for improved conversion technology,
- the lack of an infrastructure for marketing wood fuel products,
- difficulties in harvesting forest wood, and
- the much higher subsidy paid for production of nuclear energy.

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Table 1. Summary of potentially available forest resources[a]

Residue type	Existing use (×10^6 tons/year)[b]	Unexploited (×10^6 tons/year)	Growth (×10^6 tons/year)
Logging residue		32	15
Other removal residue		9	8
Fuel treatment (timberland)		49	
Fuel treatment (other forestland)		11	
Fuelwood	35		16
Wood residues (forest products)	46	8	16
Pulping liquors (forest products)	52		22
Urban wood residue	8	28	11

[a] From Perlack et al. (2005).
[b] Multiply ovendry tons by 0.9072 to obtain ovendry tonnes.

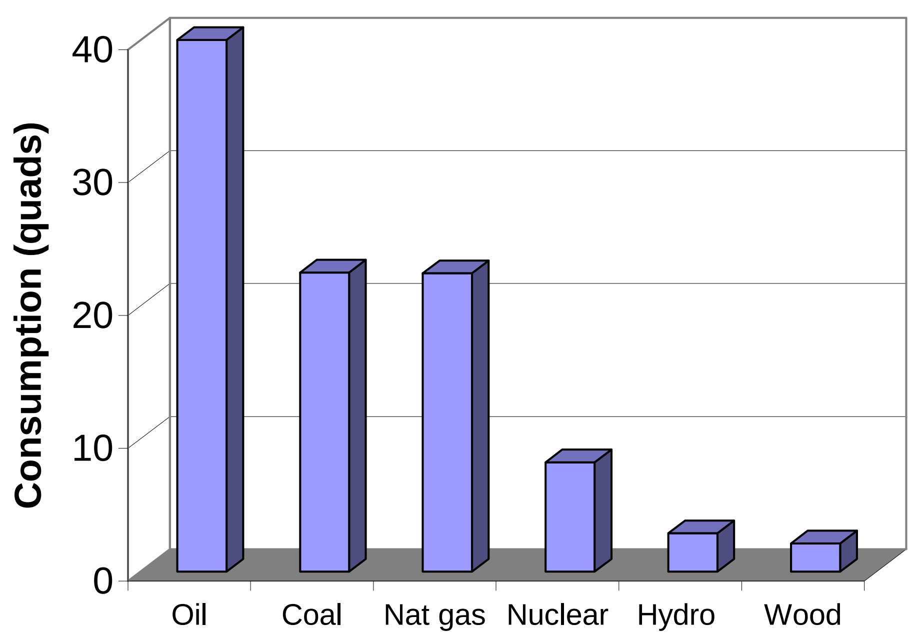

Figure 1. U.S. energy consumption, 2006. From USDOE (2007).

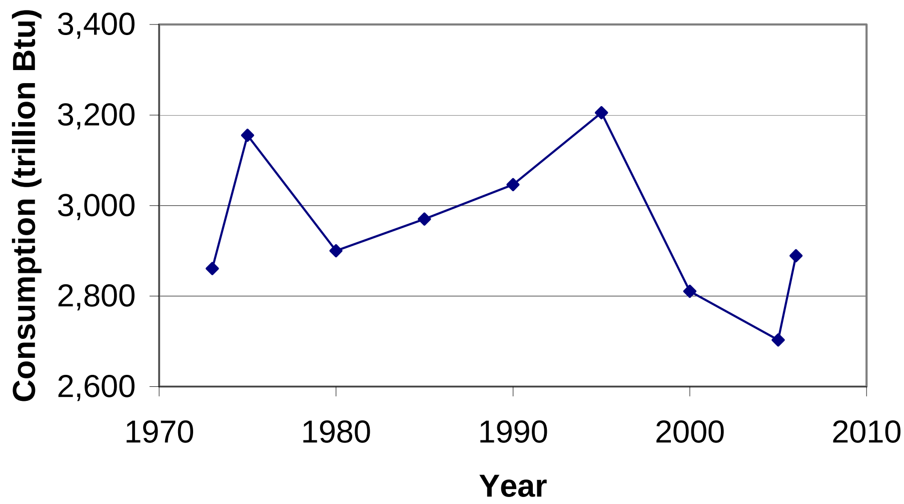

Figure 2. Consumption of wood for energy, 1973 to 2006. From USDOE (2007).

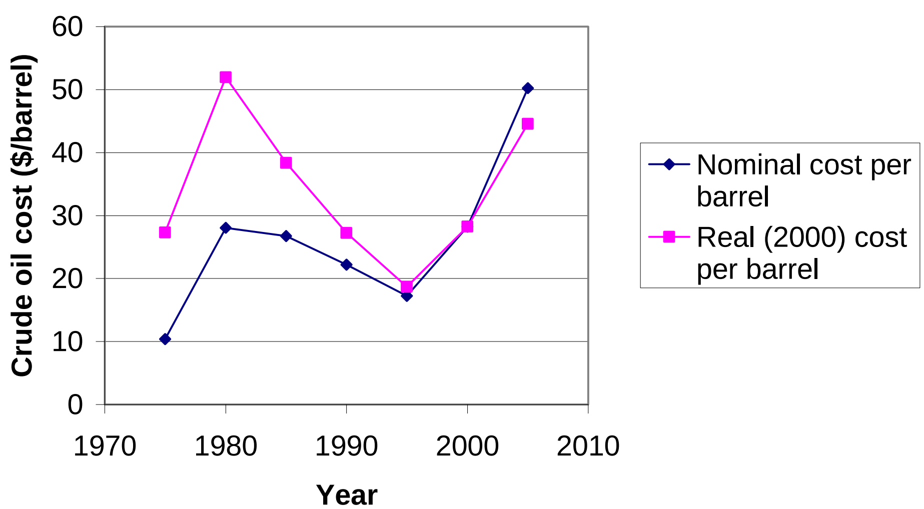

Figure 3. Average refiner acquisition cost for crude oil. From USDOE (2007).

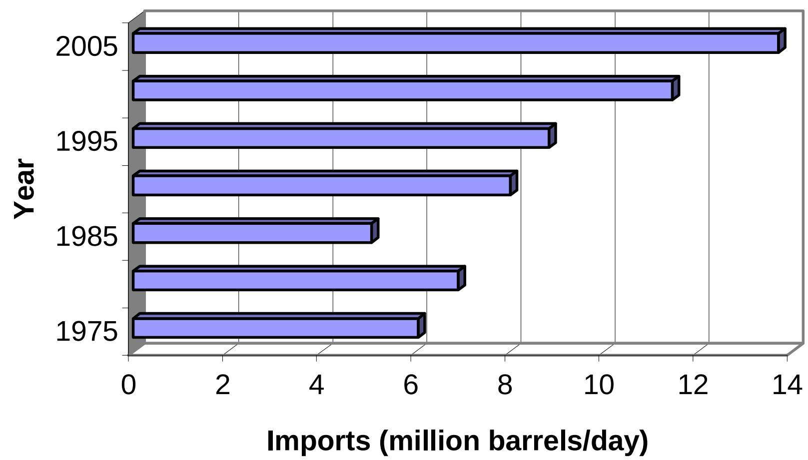

Figure 4. Daily oil imports, 1975 to 2000. From USDOE (2007).

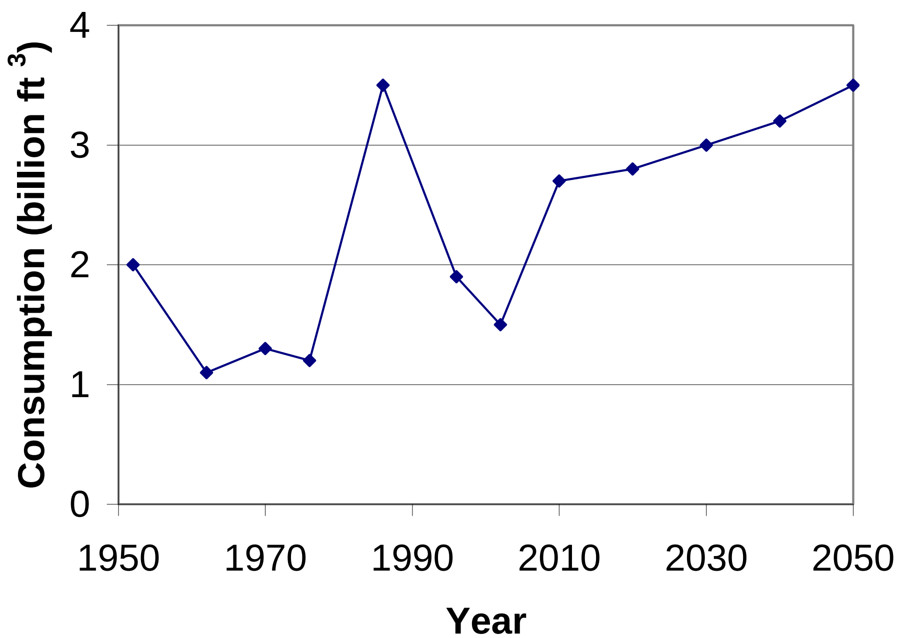

Figure 5. Historical and projected apparent roundwood consumption for fuelwood in the United States. From USDA Forest Service (2007).