By John I. Zerbe

With the high cost of refined products from crude oil, it is important to find less expensive alternatives. It is also desirable to reduce fossil fuel consumption to alleviate harmful effects of global warming. This would mean use of more renewable fuels and, possibly, nuclear energy, although there is less concern about global warming in this country than in most other counties.

We should do all we can to use energy from residue wood efficiently and economically, and thereby conserve fossil fuel and reduce high costs incurred through use of petroleum-based fuels. The Energy Policy Act of 2005 should be a big help.

We can have the greatest direct impact on petroleum and natural gas fuel usage by burning or gasifying wood for space heat, process energy and power. One alternative source that is available and underused is surplus wood.

Certainly wood that is suitable for use in more valuable products should not be diverted to energy use that provides less income; however, other wood is unused or even burned or landfilled for disposal. Such wood is well suited for energy applications.

This wood includes small wood that should be removed from stands of timber for fire protection or in regular thinnings in accord with good forest management, "noncommercial" timber (rough trees, rotten trees, and salvageable dead trees), harvesting residues (growing and non-growing residues, uncut trees, and bark), soft wood and hardwood removals (land clearing, stand improvement), insect and disease killed trees, manufacturing residues, and construction/demolition waste.

A 1980 report (USDA 1980) estimated the unused wood available annually for energy in the United States as equivalent to 544 million metric dry tons of energy. This could translate into 1,675 million barrels of oil. A 2005 report estimates that forestlands in the contiguous United States can produce 334 million dry metric tons (368 million dry tons) of biomass for energy annually. Thus it is likely that through the use of existing inventory and expanding productivity and accessibility of forest biomass it would be possible to obtain 10% of our energy needs from forest biomass.

Wood Energy Technology Options

The most effective way to use wood biomass for energy is to combust it efficiently through direct burning. Combustion systems include boilers or other combustors, plus any emission control equipment as well as in-plant fuel preparation equipment. Different combustors can use different types of particulate or fireplace-length fuel. Research has also been applied to burn whole-tree length wood units. Wood fuel may be burned dry or with moisture contents (MCs) up to about 60% based on wet weight.

Uniformity of fuel facilitates combustion control and overall process efficiency. Net boiler efficiencies may range from 60% for green wood at 60% MC to 80% for ovendried wood. In some applications, wood may be co-combusted with coal or natural gas to reduce sulfur emissions.

Pyrolysis is another method that can be used, and it means heating a material such as wood in the absence of oxygen or in the presence of limited amounts of oxygen that are insufficient to support complete combustion. Products of pyrolysis are liquid, char, and gas. Lower pyrolytic temperatures will produce higher proportions of liquid and char and lesser amounts of gas. Higher pyrolytic temperatures will produce more gas.

In mid-2005, there was renewed interest in "flash pyrolysis" to produce liquid bio-oil. In this process, organic materials are heated rapidly to 450° to 600°C (822° to 1112°F) in the absence of air. Typically 70 to 75 weight percent of the feedstock is converted into oil. The oil can be used for a variety of products. The oil is somewhat corrosive, but with appropriate treatment it could conceivably be used for diesel fuel.

Another approach to gaining an improved fuel from a pyrolytic process is to manufacture charcoal. Charcoal is produced by heating wood in airtight ovens or retorts.

Since the 1960s, the charcoal industry in the United States has stagnated. However, manufacture of charcoal provides an improved fuel compared to wood as it is resistant to attack by insects and decay, and it is more easily transported. A serious disadvantage in the use of charcoal is that the conversion process entails a potential fuel yield that is only about 49% or less of the energy content of the original wood.

A fairly efficient option for using wood energy is gasification. This method of producing alternative fuels flourished in some countries before and during World War II when petroleum supplies were tight. Cars run by gasifiers worked somewhat better with charcoal than with wood. Because of some operational disadvantages, the technology disappeared soon after the war. Gasification is an efficient process, even at a small scale, and can be used for mobile or decentralized energy conversion systems.

Gasification to provide energy for generating electricity may enable efficiencies of 22 to 37% in comparison to efficiencies of 15 to 18% with steam provided by combustion. Gasification could be used with internal combustion engines or gas turbines.

One alternative form of wood energy that is gaining momentum is wood pellets. Pellets and briquettes are more fully processed and refined than chips, sawdust, chunkwood, and other forms of particulate solid wood. Pellets and briquettes are more uniform in size, MC, and other physical properties such as ash content.

Pellets are made by hammer-milling wood into sawdust. If necessary, some drying may be done at the same time as milling. The sawdust is fed into a pelleting machine where it is subjected to high pressure and extruded through a die. Wood chips do not possess the good free-flowing characteristics of wood pellets. Wood pellets are readily combustible and well suited for use with sophisticated and automatically controllable appliances.

Electrical Generation and Cogeneration

There are four main options when it comes to electrical energy generation using wood — gasification, steam turbine, gas turbine and fuel cell.

Gasification of wood is an old technology, but not necessarily a mature technology.

Community Power Corporation (CPC) in Littleton, Colo. has demonstration gasifiers paired with internal combustion engines and power generators operating in the 5-kW to 15-kW range, and it has 50-kW and 100-kW units under development.

CPC has made significant improvements in tar filtration and computerized operating control in the design of its units. CPC also has provision for collection of waste heat from cooling gas before it enters the engine. Use of this heat for drying wet wood chips to 25% MC can improve the efficiency of the gasification process from 55% without heat recovery to 75% with heat recovery. Utilization of waste heat from the engine exhaust and cooling systems could further increase efficiency. This technology is promising for highly efficient and economical power production in the future.

Besides internal combustion engines, steam engines or Stirling engines (both external combustion types) might be operated with energy from gasification or combustion to provide mechanical force to drive generators or other machines such as compressors for air-conditioning and refrigeration units, similar to the types of air-conditioning units used in cars. Steam engines have a long history. They were operated with wood fuel almost exclusively in the early days of railroading and transportation on river steamboats.

Most electric power from wood is produced with steam-driven turbine/generators. There are wood-fired power plants up to about 75 MW around the country. Wood-powered power plants of 10 to 20 MW are more common.

The average biomass-to-electricity efficiency of the industry is 20%. Perhaps the nearest term low-cost option for the use of biomass in power generation is co-firing with coal in existing boilers.

Cogeneration or combined heat and power (CHP) enables more efficient utilization of wood than production of electricity only. In an electricity-only process, all of the steam is condensed in the turbine cycle; in CHP operation, a portion of the steam is extracted to provide process heat.

The addition of dryers and incorporation of more rigorous steam cycles is expected to raise the efficiency of direct combustion systems by about 10% over today's efficiency and to lower capital investment costs from the present $2,000/kW to about $1,275/kW.

When using wood fuel in gas turbines it is necessary to use a clean and clean-burning non-corrosive gas. There are various gasification technologies to produce medium or low-calorific gas from wood. These processes along with gas cleaning processes are improving. In integrated gasification combined cycle systems, the steam for the bottoming turbine is produced from heat recovered from the gas turbine cycle.

Fuel cell technology is highly efficient for the production of electricity at various scales. Use of wood to provide fuel for fuel cells could involve conversion of wood to hydrogen for direct use in fuel cells, conversion of wood to methanol for direct use of methanol in fuel cells, reforming methanol or ethanol from wood to hydrogen for use in fuel cells, or conversion of wood to low- or medium-calorific gas for use in fuel cells. Different types of fuel cells would be nec-

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essary for these different approaches. It will probably be a matter of a decade or more before these details can be worked out, and different approaches will be needed for different applications.

Energy Policy Act of 2005

The Energy Policy Act of 2005 helps all renewable fuels by various provisions. There is a production tax credit of 1.8 cents per kWh for many renewable energy options if they are on-line by the end of 2007.

The Secretaries of Agriculture and Interior are given various authorities. Grants up to $20 per green ton of biomass may be made to owners or operators of facilities that use biomass as a raw material to produce electricity, sensible heat, or transportation fuels. Grants up to $500,000 may be made to persons to offset the costs of projects to develop or research opportunities to improve the use of, or add value to, biomass. For the grant programs there is an appropriation authorization of $50,000 for each of the fiscal years 2006 to 2016.

The grant authorizations and production tax credit should certainly help in extending and establishing direct burning and gasification operations The Secretary of Interior is also asked to seek approved non-hydropower renewable energy projects located on public lands with a generation capacity of at least 10,000 MW of electricity in 10 years.

Analyzing the Future of Wood Energy

Next to hydropower, wood is the most important renewable energy source, and during periods of drought and lowered snow cover on the mountains of the West, wood provides more energy than hydropower. To maintain healthier forests, it is important to remove more material that contributes to dangerous forest fires from forest stands. Much of this wood is more valuable for use as energy than when used for other purposes.

Air and water emissions from burning wood are less problematic than from burning or gasifying coal. With coal there can be problems with sulfur, mercury, and other heavy metals, which don't occur with wood. Air emissions of particulates from burning wood can be reduced with catalytic converters for combustion of unburned hydrocarbons and treatment of exhaust gases through proper individual or combined methods of filtering, scrubbing, and precipitating.

In the United States, we could and should be getting 10 percent of our energy consumption from wood. It is possible to grow to this level from the current supply of 3.1% of our energy consumption by applying good forestry practices and using more wood residues.

The time is right for implementing available technology in using wood for energy in order to gain economic and environmental advantages. Expansion of infrastructure is also needed (roads, machinery for small-diameter removal, and processing plants) to improve accessibility, harvesting, and the production of wood fuel.

Unless there is greater implementation of the current state of technology, research to improve technology, and infrastructure is given a boost, we cannot make more progress in the next 25 years than we have in the past 25 years.

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