Findings and Conclusions

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1. Technologies for wood use could affect future U.S. timber requirements in two ways: 1) by extending the wood resource through improved product recovery and 2) by substituting wood for nonrenewable materials.

The United States currently has abundant productive timber resources compared to those of most other industrialized countries. However, the U.S. Department of Agriculture's (USDA) Forest Service forecasts possible shortfalls in the year 2030 of domestic timber species and sizes currently used for structural materials, pulp, and paper. At the same time, the U.S. forest products industry sees a potential for increased export of wood products and a more active U.S. role in world wood trade, Technology will play a major role in both extending timber resources and developing new and improved ways to use wood,

Il. **Existing and emerging manufacturing technologies could increase wood product yield significantly and may result in increased utilization of forest residues for industrial energy production.**

Because nearly half of all industrial forest products are lumber and structural panels, increased yield of these products alone could have a major impact on domestic timber demand. However, increased yield of solid wood products also could reduce the amount of waste wood available for energy generation in lumber mills and pulpmills, a situation that could stimulate greater use of forest residues and other biomass in the forest products industry, Lumber products, generally used for structural support, are long, thin, rectangular pieces of solid wood. Panel products often are used for structural sheathing and generally are manufactured in 4-by 8-ft sheets usually less than *1* inch thick. Pulp products include paper and paperboard, films, and fabrics,

The amount of roundwood required for lumber production could be reduced 20 to 40 percent by using currently available technologies such as Best Opening Face (BOF), saw-dry-rip (SDR), or edge-glue and rip (EGAR), although it will take several years to achieve even a 20-percent reduction. Such savings would be significant, since lumber consumption of over 50 million tons in 1979 accounted for about half of all wood products consumed.

Composites— such as parallel-laminated veneer (PLV) and corn-ply-are probably the most material-efficient lumber products. They are manufactured by gluing veneers or particles together and sawing the resulting boards into a variety of products. Use of these processes can increase lumber recoveries 40 to 90 percent or more. However, this technology is not yet used on a large commercial scale (probably less than 1 percent of all lumber products are composites]; such technology would require new facilities entirely different from those in conventional lumber mills. Even though composite lumber products offer increased lumber recovery and use of lower quality wood, they are unlikely to replace conventional sawn lumber to any great extent during the next two decades because of the large capital investment requirements, high variable costs (e. g., glue costs), and possible problems resulting from formaldehyde emissions from adhesives.

Adoption of several new technologies could increase lumber recovery of existing mills up to 30 percent without major plant alterations. Among these are the BOF program and the EGAR process. BOF is a computer-assisted method for increasing lumber volume and grade by optimizing sawlines. Laboratory tests and some inservice tests indicate that BOF could increase lumber yields by more than 20 percent. EGAR is an innovative sawing-and-gluing technique that reduces loss of wood in the sawing process, can increase lumber recovery 10 to 13 percent, and permits the use of lower quality raw material.

Product yields in the manufacture of composite wood panels are 75 to 80 **percent by weight, compared with the average current plywood recovery of about** 50 **percent.** Composite wood-panel products (particleboard) are manufactured from woodchips, flakes, wafers, or strands that are glued and formed into plywood-like sheets. Composite panels with the strength of plywood are now being produced and eventually will substitute for plywood in many structural uses.

Substitution of composite wood panels for plywood already has begun, and substantial additions to waferboard and oriented strand board (OSB) production capacity has been completed, Composite panels will begin to replace significant amounts of plywood in structural use by the middle of the decade, Within 10 to 20 years, it is likely that these products will replace most construction plywood, Limits on production of composite panels probably will have more to do with access to investment capital in processing facilities than with institutional or technological constraints.

Increased use of improved mechanically produced pulps can increase fiber yields from about 50 percent to almost 95 percent, reducing wood requirements to 1.05 tons per ton of paper. Over 75 percent of current U.S. pulp and paper production is from the relatively low-yielding kraft chemical pulping process. Since about one-third of industrial roundwood in the United States is used for pulp and paper (53.5 million tons in **1979),** a significant improvement in overall fiber recovery would result if highly efficient mechanical pulping replaced chemical pulping. For example, thermomechanical pulping (TMP)—an improved mechanical pulping process that produces higher quality paper than other mechanical processes—could displace about 300 pounds of the kraft paper currently used in each ton of newsprint. Opportunities also may exist for reducing the amount of kraft pulp used in other printing papers. There probably are practical limits, however, on the extent to which mechanical pulps can substitute for chemical pulps, because high-strength and permanently bright papers cannot yet be manufactured from mechanically produced pulps.

Opportunities for improved mechanical pulps to make significant contributions to pulp consumption over the next two decades are reasonably good. Production of improved mechanical pulps already has begun and is expected to expand.

III. Technology could expand the use of currently abundant hardwood species, enabling use of wood material now underutilized.

Over one-third of the total volume of existing U.S. timber is hardwood. Hardwood inventories are increasing at a rate over six times that of softwoods, which have been more heavily utilized because of their superior properties for the manufacture of many conventional wood products. In the Eastern United States, hardwoods comprise over 62 percent of the standing timber, yet account for only 44 percent of the harvest. Thus, in the East, and particularly in the South, hardwoods are a significant and underutilized wood resource. Because of their wood qualities, softwoods currently are preferred for manufacture of lumber, plywood, and some types of paper, However, existing and emerging technologies may be capable of using hardwoods to make many products that are now produced mostly from softwoods.

Composite lumber and particleboard, which can be manufactured from hardwoods, could substitute for softwood lumber and plywood. In addition, SDR technology could enable the manufacture of high-quality sawn lumber from underutilized and abundant hardwood species, SDR is a modification of the normal sequence of lumber processing that may reduce defects and waste in hardwood lumber manufacture. The SDR process maybe adopted without major equipment changes or additions to existing mills.

Increased use of hardwoods for pulp and paper may be possible with the adoption of mechanical and chemimechanical pulping technologies. Hardwood species are used extensively for the production of newsprint and fine printing papers. However, papers manufactured from hardwoods are weaker than those made from softwoods, which have long fibers; thus, their end use is limited to applications where paper strength is not of prime importance. Chemimechanical pulping (CMP), which involves chemical treatment of wood prior to grinding, may be able to produce strong hardwood papers that could displace or supplement the use of some softwood papers,

Press-dry papermaking technology offers perhaps the greatest opportunity to expand future hardwood utilization. Press drying, which produces paper from hardwood pulp using high pressure and high temperatures during part of the papermaking process, could produce heavy-duty linerboard with strength properties generally superior to those of conventional kraft linerboard. Linerboard currently uses about one-fourth of the wood pulp produced in the United States (approximately 13 million tons/yr), and prospects are good for increasing linerboard exports. Response to the markets and a combination of press-dry technology and hardwood CMP in the production of linerboard, could expand significantly the use of several currently underutilized hardwood species. Softwood pulps also can be processed by press drying, but the principal advantage of the technology is that it enables manufacture of high-strength papers from hardwoods. The press-dry process was developed by the U.S. Forest Products Laboratory (FPL) and requires further modification and testing before it can be commercialized.

IV. Conservation of solid wood materials through increased recycling of waste paper and improved structural design could reduce demands for wood.

Approximately one-fourth of the total paper pulp produced in the United States annually comes from recycled paper. Recycling presents some opportunities for energy conservation. The use of 14 percent recycled fiber for the manufacture of newsprint, for example, could reduce electricity consumption in paper making by 7 to 10 percent. Two major barriers to increasing recycling remain, however, in the United States: 1) used paper usually is contaminated with glue, ink, and other materials that are expensive and difficult to remove; and 2) the economics of waste-paper collection and transportation make recycling generally unprofitable, except in metropolitan areas. Only a few paper mills operate with recycled paper alone; most often, they blend it with virgin pulp, which lends strength to the weaker, recycled fibers. The practical upper limit for using recycled fiber in furnished paper is about 40 percent.

Some construction techniques and designs can reduce structural wood products requirements in residential construction by nearly one-third. Since over 50 percent of the lumber and panel products consumed in the United States are used for residential and nonresidential construction or structural maintenance, significant savings in total wood consumption could be realized from a modest reduction in construction wood use. Designs that rely on the interaction of individual building components for structural strength–e.g., truss framing, wall and floor assemblies, and sandwich panels that replace framing and sheathing—also conserve wood. Penetration of these innovations into construction markets is likely to be slow, however, due to the conservatism of building codes, the construction industry, and home buyers. Also, some current trends, such as the use of wider framing lumber for increased energy efficiency, may result in increased structural requirements.

V. New pulping technologies could reduce energy requirements for pulp and paper making and even produce additional energy for outside sale.

An estimated one-half of the wood (both industrial roundwood and other wood) removed from U.S. forests, over 120 million ovendried tons, eventually is consumed for energy production. Almost two-thirds of the wood fuel burned in 1981 was consumed by the wood products industry. The pulp and paper sector alone accounted for about 3 percent of total U.S. energy consumption. As a result of this large energy usage, pulp and paper manufacturers have become industrial leaders in energy conservation and electric cogeneration.

Innovations could boost waste heat recovery in mechanical pulping for use in paper drying, space heating, and water treatment. In addition, use of pulping technologies such as pressurized groundwood (PGW] pulping, CMP, and chemithermomechanical pulping (CTMP), would result in lower energy requirements than those of TMP and chemical pulping technologies.

Process improvements in chemical pulping may allow mills to approach energy self-suf-

ficiency. Among the strategies available to reduce energy consumption are: 1) increasing the use of wood waste in cogeneration, 2) using spent pulping liquor more efficiently for fuel, and 3) recovering low-quality energy more efficiently through heat pumps and heat exchangers.

Improvements in drying technology offer the greatest opportunities for reducing energy consumption in lumber and panel manufacturing because about 70 percent of the average energy consumption is used in kiln operations and panel drying. Solar kilns, vacuum kilns, and microwave drying are current options for reducing energy consumption. Improved operation of conventional steam-heated kilns through use of sensors and computer controls also provide opportunities for reducing energy consumption.

Improvements in residential stove and furnace design and in technologies for producing industrial wood energy could probably raise the efficiency of direct wood-fuel combustion to 80 percent of the heat-producing potential of the wood. Conversion from open fireplaces to efficient wood stoves could change wood fuel-use efficiency from negative values (heat loss) to as high as 50 percent. Use of self-stoking furnaces, heat storage devices, and circulating systems could raise residential wood-use efficiencies to 80 percent of the fuel's heat potential. In larger commercial and industrial applications, fluidized-bed burners can achieve efficiencies of up to 80 percent, though current efficiency averages 70 percent. Gas turbine technologies coupled with fluidized-bed burners could efficiently cogenerate electricity if technologies were developed to cleanse the combustion gases.

It is feasible (but uneconomical using existing chemical technologies) to convert forest biomass to chemical feedstocks and intermediate products that are currently extracted from petroleum. These may be transformed into nearly all the major industrial organic chemicals. Optimistic projections indicate that liquefaction, gasification, pyrolysis, and hydrolysis of less than 60 million tons of wood and wood residues theoretically could supply a significant proportion of the synthetic polymers currently consumed in the United States. However, the complex processes required for their manufacture are uneconomic at this time. Production of ethanol and methanol from wood and the oxygen gasification of wood could result in production of liquid fuels and syngas for energy conversion.

VI. New **wood products may serve as substitutes or complements for materials derived from nonrenewable resources.**

For example, composite materials made of wood and fiberglass, plastics, or metal have demonstrated superior performance in some applications, although these composites currently account for only a small proportion of the total wood materials used. Experiments at FPL have demonstrated the technical feasibility of producing very stiff, high-strength paper, which, with further development, may some day be used for wall sheathing or modular structural panels. Tests of paper construction materials have yielded mixed results, and a significant amount of additional work is probably needed before paperboard could become a major structural material.