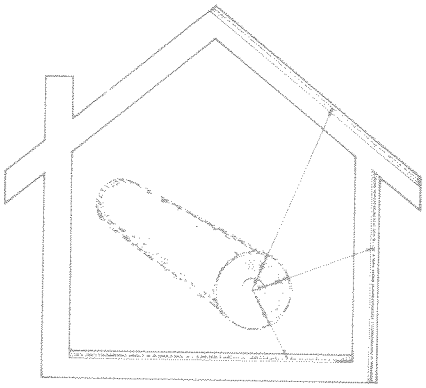
U.S. Department of Agriculture
Forest Service Research Paper SE-201



COM-PLY® REPORT 17

ECONOMIC FEASIBILITY OF MANUFACTURING COM-PLY PANELS IN THE SOUTH

COOPERATIVE RESEARCH

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December 1979

Southeastern Forest Experiment Station

Asheville, North Carolina

Economic Feasibility of Manufacturing Com-ply Panels in the South

by

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Cooperative Research by
U.S. Department of Agriculture, Forest Service
Southeastern Forest Experiment Station
and
U.S. Department of Housing and Urban Development
Division of Energy, Building Technology
and Standards

PREFACE

This report is one of a series on the possibilities of producing house framing and structural panels with particleboard cores and veneer facings. These COM-PLY or composite materials were designed to be used interchangeably with conventional lumber and plywood in homes. Research on structural framing was initially limited to COM-PLY studs but has now been extended to include larger members such as floor joists.

In 1973, the home-building industry faced a shortage of lumber and plywood and consequent rising prices. Both industry and government recognized that this was not a temporary problem and that long-range plans for better using the Nation's available forest resources would be necessary.

The Forest Service of the U.S. Department of Agriculture and the U.S. Department of Housing and Urban Development accelerated cooperative research on ways to utilize the whole tree. They concentrated on composite wood products made with particleboard and veneer as a way of using not only more of the tree stem, but also using less desirable trees and a greater variety of tree species than would conventional wood products. The particleboard which comprises a large portion of COM-PLY studs and joists is made from chipped-up wood that comes from forest residues, mill residues, or low-quality timber. Thus, such composites could greatly increase the amount of lumber and plywood available for residential construction, our major use of wood, without eroding the Nation's timber supply.

Research on composite wall and floor framing was performed by the Wood Products Research Unit, Southeastern Forest Experiment Station, Athens, Georgia. The American Plywood Association cooperated in these studies by designing and testing composite panel products that are interchangeable with plywood. Both types of products have been incorporated in demonstration houses.

Included in this series will be reports on structural properties, durability, dimensional stability, strength, and stiffness of composite studs and joists. Other reports will describe the overall project, compare the strength of composite and solid wood lumber, suggest performance standards for composite lumber, and provide construction details on houses incorporating such lumber. Still others will explore the economic feasibility of manufacturing composite lumber and panels and estimate the amount and quality of veneer available from southern pines. These reports, called the COM-PLY series, will be available from the Southeastern Forest Experiment Station and the U.S. Department of Housing and Urban Development.

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ACKNOWLEDGMENT

The Forestry Sciences Laboratory, Wood Products Research Unit, acknowledges the valuable assistance and guidance of:

Harold Evans
Consultant for Plywood and
Panel Products

Economic Feasibility of Manufacturing Com-ply Panels in the South

Abstract.—Investments, production costs, and probable returns for manufacture of COM-PLY panels in the South are presented. It is possible to obtain a 20 percent or greater after-tax internal rate of return on an investment in manufacturing COM-PLY panels. This study shows that a manufacturing system that assembles the panels in two stages is more economic than a system that assembles the panels in a single stage.

KEYWORDS: Manufacturing costs, sheathing cost, economics of panel manufacture, cost analysis, plywood costs.

Cooperative research by the Forest Service, U.S. Department of Agriculture, and the U.S. Department of Housing and Urban Development has led to development of a new composite panel product. The new product, called COM-PLY, has potential for significantly increasing our supply of sheathing for building homes. COM-PLY panels are intended to be direct substitutes for plywood panels now widely used for roof and floor sheathing. COM-PLY panels are a structural sandwich construction with a 0.3-inch-thick particleboard core placed between 0.1-inch-thick layers of solid wood veneers (fig. 1). The first composite panel products developed were roof and floor sheathing. Information on performance of these panels is summarized in COM-PLY Report 3 (Carney 1977).

COM-PLY panels need to be priced competitively with plywood so builders will have incentive to purchase them. Potential manufacturers of COM-PLY panels want to know how much it will cost to manufacture COM-PLY panels. They also want to know if a COM-PLY panel factory would be a profitable investment, one that would have a greater rate of return on the investment than a plywood factory. This report presents estimates on the amount of investment required to build a particleboard, veneer, and panel-laminating factory; the annual sales and cost of manufacturing COM-PLY panels and operating cash flows; and the annual net cash flows and internal rate of return.

Any financial feasibility study is only as good as the assumptions upon which it is based. In this study, we assumed that the factory would be located in Arkansas and would use southern pine wood. The assumptions concerning costs are based on industry averages and therefore do not reflect values for any specific company.

Results presented in this report do not guarantee that any firm can profitably manufacture COM-PLY panels—profitability depends on competent managerial skills, market demand, production efficiency, and other business factors. The results strongly indicate that it is economically feasible to manufacture COM-PLY panels. Although a specific firm's price, assumptions about cost, and quantity may vary from those assumed in this report, minor variances would not affect the overall conclusions reported. Companies contemplating the manufacture of COM-PLY panels should substitute their own local cost estimates in a similar analysis to check economic feasibility for their particular location.

FINANCIAL FEASIBILITY ANALYSIS

PROCESSES USED FOR MANUFACTURE

Feasibility of any manufacturing venture is greatly affected by the processes used. In this report, two methods of production are analyzed. In the first method, referred to as Case I, a prepressed mat of wood particles coated with

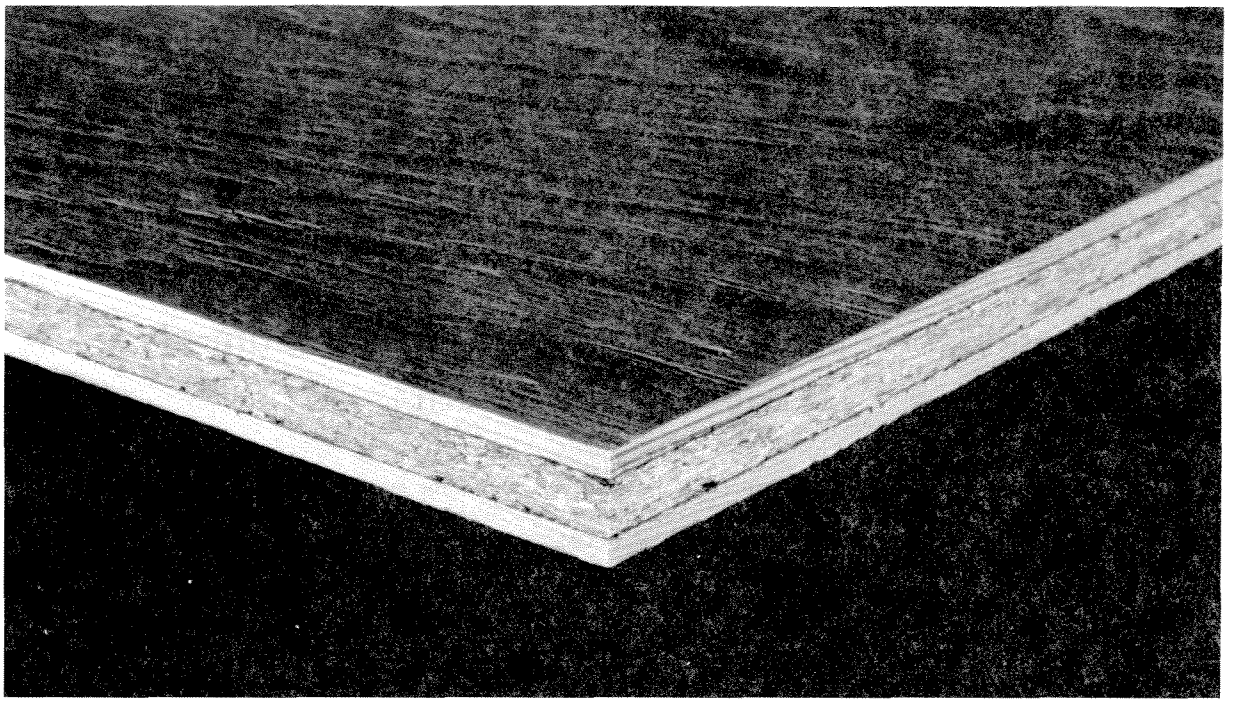

Figure 1.–COM-PLY panel used for sheathing roofs of houses.

resin is placed between two sheets of veneer. A number of these veneer-mat assemblies are loaded into a high-pressure multiplaten hot-press to cure the resin in the flakeboard and bond the veneer to the flakeboard in a single stage. In the second method, Case II, 4- by 8-foot flakeboard panels are made by the conventional methods for manufacturing particleboard. Then, these flakeboard panels are placed between two sheets of veneer and the veneer is bonded to the flakeboard in a conventional low-pressure plywood press, using conventional plywood glue. Case II is a two-stage operation and requires a particleboard press line and a panel press line. Panels made by Case I and Case II methods are identical.

Process for Case I

Veneer blocks are debarked, steamed, and rotary cut as they would be in a plywood plant. The veneer is clipped, dried, and graded in much the same manner as veneer for plywood. Unlike plywood, however, COM-PLY panels do not have veneer crossbands. Since all veneer is used as panel facings, equipment must be available to edge-bond narrow strips of veneer into sheets wide enough for panel facings.

The peeling residues (core, roundup, and block trim) and the portions of pine stems too small or crooked for peeling are used to make flakes for the flakeboard core of COM-PLY panels. The peeler cores are fed endwise through a rotary flaker which shaves the peeler core into flakes much like a huge pencil sharpener. The ideal flake is 0.19 to 0.31 inch wide, 1.25 to 1.75 inches long, and 0.02 to 0.03 inch thick. Flakes wider than 0.31 inch may curl, making them difficult to coat uniformly with resin during the blending operation. The flakes need to be 3 to 7 times longer than they are wide because the flakes must be oriented with their grain across the COM-PLY panel. Processes for orientating flakes either mechanically or electrically require flakes that are longer than they are wide. High-quality flakes of the type just described should make up about 60 percent of the furnish in the flakeboard. The remaining wood particles can come from bark (not more than 5 to 7 percent of the board) or other forest and mill residues. Some fine material and particles not having the ideal shape can be used.

Particles can be oriented at low cost. To understand the process, visualize a toothpick dropped into a piece of paper with a V-shaped fold. The toothpick aligns itself in the direction of the V-groove. Other particles also will do so if they are longer than they are wide. Next, visualize a cylinder with its longitudinal axis in a horizontal position and having V-grooves on its circular surface. Wood particles are dropped onto the cylinder and align themselves in the V-grooves. As the cylinder turns, the particles are dumped out to form a mat whose particles are aligned in the direction of the V-grooves on the cylinder. Other operations such as blending, forming, and prepressing are very

similar to well-known methods of particleboard manufacture. Sheets of face veneer approximately 54 by 102 inches are passed under the forming stage, and a mat of oriented flakes that has been blended with resin and wax is laid on top of the veneer. Then, a second sheet of veneer is placed on top of the mat. This veneer-mat assembly must be prepressed and hot-pressed. A disadvantage of this process is that long press times are required to heat through both the veneer and the flakeboard assembly. Finishing operations, such as panel patch, plug, trim and sanding if required, are similar to those used for making plywood.

Process for Case II

Veneer processing, flake preparation, and finishing of panels are the same as for Case I. For Case II, 4- by 8-foot flakeboard panels are made in a standard multiplaten particleboard hot-press. These panels have the flakes oriented with their lengthwise direction across the panel (in the 4-foot direction) as in Case I. For a 1/2-inch-thick COM-PLY panel, the flakeboard is 0.3 inch thick and will have two 0.1-inch-thick veneer facings added to it in a subsequent stage. An advantage of the Case II method is the short press time for flakeboard cores. After the flakeboard panels are made, veneer is glued to each face with standard plywood adhesive in a multiplaten plywood hot-press. A glue spread rate of 40 lb/Mft^2 of glueline is used. This operation is faster than making plywood panels for two reasons. First, the press cycle is short because only the face veneers must be heated hot enough to cure the glue. In making plywood, heat must penetrate to centrally located gluelines. Second, the veneer-core layup operation can be easily automated for rapid assembly. Layup of crossbands in plywood is slow and difficult to automate.

INVESTMENT REQUIREMENTS

Land

A COM-PLY panel plant would require about 30 acres, and land cost was assumed to be $8,950 per acre. Thus, total land cost would be $268,500. Land-developing costs for such things as engineering, overhead, and contingencies were assumed to be $51,000. Thus, the total cost of land and development is $319,500.

Buildings

A main building with 150,000 square feet, constructed at a cost of $8.40 per square foot, and miscellaneous small buildings with 7,000 square feet, constructed at a cost of $10.98 per square foot, would be required in Case I. Costs would be $1,260,000 and $76,900 for these structures. For Case II, a main building with 170,000 square feet and miscellaneous small buildings with 10,000 square feet are required. The structures for Case II would cost $1,428,000 and $109,800, respectively. Engineering design, construction overhead, and contingencies add $500,000 to the basic building cost for each case, and total costs for buildings are $1,836,900 for Case I and $2,037,800 for Case II.

Facilities

Cost of facilities to be added to the buildings and grounds in order to make the factory operational are:

Facility	Cost	
	Case I	Case II
	(dollars)	
Site preparation	30,000	30,000
Roads, parking, and paving	30,000	30,000
Outside fire protection	48,000	48,000
Outside lighting	3,600	3,600
Outside piping (water supply and sewer)	12,000	12,000
Waste disposal	6,000	6,000
Fuel storage (gas and diesel tanks and pumps)	6,000	8,000
Inside electrical equipment (installed)	528,000	633,600
Inside piping (air, water, sewer)	43,200	51,800
Engineering, construction overhead, and contingencies	353,400	411,500
Total	$1,060,200	$1,234,500

Machinery

In this study, it was assumed that new machinery was purchased. Table 1 lists machinery and its cost for both Case I and Case II methods of panel manufacture. The number and size of machines required depend on the flow of materials through the factory. A number of choices are available. We chose one combination of machines for each case. Installed cost of machinery is $6,763,050 for Case I and $8,554,100 for Case II. Both Cases I and II use a 4- by 8-foot by 30-opening press for final panel assembly. However, Case I requires a single 30-opening high-pressure press, while Case II uses a low-pressure 30-opening standard plywood press to apply veneers to flakeboard cores and a 4- by 24-foot by 14-opening standard high-pressure particleboard press for making cores. Also, Case II requires two veneer driers to handle the larger flow of veneer associated with that process. Otherwise, the panel-making machinery is the same for both cases.

Cash

In this analysis, we assume that the equivalent of 2 months' payroll is sufficient cash to meet the payroll, provide petty cash, and otherwise meet cash needs to operate the business. In a later section, we show that the annual labor cost in 1975 would be $1,322,184 for Case I and $2,004,168 for Case II if the plant were operating at 100 percent capacity. Thus, cash required was assumed to be $220,364 for Case I and $334,028 for Case II.

Inventory

Investment is required for raw materials, for materials being processed, and for finished products awaiting shipment. In this study, one-sixth of the annual cost of raw materials for a factory operating at full capacity was assumed to be sufficient to cover all requirements for inventory investment. It will be shown that the total annual cost of raw materials for Case I is $3,061,946 and $7,144,221 for Case II. Therefore, the investment required for inventory is $511,344 for Case I and $1,193,085 for Case II.

Accounts Receivable

A considerable investment is required to cover sales to customers who do not pay immediately for the products purchased. These accounts receivable may typically be paid in 10 to 60 days. The average collection period from customer sales was assumed to be 30 days. Investment to cover accounts receivable was considered to be 1 month (30 days) of sales. Sales will vary with the unit price received for products and the quantity produced each year. In this study, we used average 1975 prices of $122/Mft^2 for grades C-D unsanded panels f.o.b. mill and $231.80/Mft^2 for A-B sanded panels f.o.b. mill. For a product mix of 80 percent C-D panels and 20 percent A-B panels, the volumes produced are 11,696,256 square feet of A-B sanded panels and 46,785,024 square feet of C-D unsanded panels per year for Case I. The accounts receivable for Case I is 1 month of sales, or $701,580. For Case II, the volumes produced per year are 25,344,000 square feet of A-B sanded panels and 101,376,000 square feet of C-D unsanded panels, or a total of 126,720,000 square feet. Accounts receivable for Case II total $1,520,218.

Contingency

The investment for any individual item, such as land or buildings, may vary from the amount assumed, and items not planned for may be required. To allow for such contingencies, we allotted 5 percent of all other investments. The totals of all investments up to this point for Case I are $11,412,938 and $15,193,230 for Case II. Five percent of $11,412,938 is $570,647, which is the contingency investment for Case I. Five percent of $15,193,230 is $759,662, which is the contingency investment for Case II.

Timing of Investments

The time when an investment is made is important in an economic analysis. Cash invested in a factory could have been invested in interest-bearing securities. In this study, we assume that the major capital investments would be made during the first 3 years of factory operation. Table 2 shows the amounts and timing of investments for Case I and Case II. The total investment for a new COM-PLY stud factory is $11,983,600 for Case I and $15,952,900 for Case II.

Table 1.–Machinery and machinery cost for a COM-PLY panel factory

Machinery or associated item	Cost	
	Case I	Case II
	..... *Dollars*	
Log storage and handling (unloaders, storage skids, sprinkling facilities)	182,250	182,250
Log-barking equipment	445,000	445,000
Machinery foundations and supports (installed)	187,000	187,000
Block-handling equipment and steam vault	238,000	238,000
Boiler	189,000	189,000
Log conveyors to lathe and foundation (installed)	41,850	41,850
Lathe and charger (installed)	261,900	261,900
Trays and tripples (installed)	75,600	75,600
Green clipper (installed)	96,000	96,000
Green veneer sorting line (installed)	92,000	92,000
Green veneer system belt	7,400	7,400
Green veneer clipper and conveyor (installed)	71,550	71,550
Core chipper (installed)	52,650	52,650
Bark conveyor (installed)	48,600	48,600
Chip-handling facility	48,600	48,600
Dryer(s) (installed)	545,000	1,090,000
Dryer feeder(s)	58,320	116,640
Dryer unloader(s)	34,630	69,760
Moisture meter	6,750	6,750
Dry-sorting chain	13,500	13,500
Dryer emission control equipment	36,450	36,450
Flaker	67,500	67,500
Fiber dryer	472,500	472,500
Fiber dryer emission control equipment	20,250	20,250
Fiber screen	8,100	8,100
Glue mixing, pumping, and metering equipment	22,950	22,950
Blender (installed)	45,000	45,000
Forming felter and caul line	735,000	735,000
Curtain coater	72,000	72,000
Semi-automatic layup system	270,000	270,000
Prepress	55,000	55,000
Particleboard press (4 ft. x 24 ft.–14 openings)		1,525,000
Board cooler and conveyor		162,000
Hot-press (4 ft. x 8 ft.–30 openings, HP)	720,000	
Hot-press (4 ft. x 8 ft.–30 openings, LP)		185,600
Hot-press loading and unloading system	210,000	210,000
Saw line	195,750	195,750
Veneer edge-gluing equipment	103,000	103,000
Veneer plugger	50,850	50,850
Packaging and strapping machine	4,500	4,500
Hog-fuel system	17,550	17,550
Forklifts and carts	90,000	90,000
Air compressor (installed)	50,000	50,000
Maintenance equipment and small tools	67,500	67,500
Sander	130,000	130,000
Sander feeder	20,500	20,500
Conveyor to grade line	5,000	5,000
Panel patch line	54,600	54,600
Patching equipment (pumps, gun, etc.)	10,000	10,000
Spare parts and quality control equipment	70,200	70,200
Sweeper and yard truck	25,650	25,650
Storage banks	80,000	80,000
Storage bins	60,000	60,000
Air conveyors (blowers, cyclones, piping)	126,000	126,000
Freight in for machinery	171,600	171,600
Total	6,763,050	8,554,100

Table 2.–Net investment required for the first 3 years of factory operation for Case I and Case II

Investment	Beginning of first year		End of first year		End of second year		End of third year		Total[1]	
	Case I	Case II	Case I	Case II	Case I	Case II	Case I	Case II	Case I	Case II
	Dollars									
Land	319,500	319,500	0	0	0	0	0	0	319,500	319,500
Buildings	0	0	612,300	679,300	1,224,600	1,358,500	0	0	1,836,900	2,037,800
Facilities	0	0	848,200	987,600	212,000	246,900	0	0	1,060,200	1,234,500
Machinery	0	0	2,254,300	2,851,400	4,508,700	5,702,700	0	0	6,763,000	8,554,100
Cash	0	0	73,500	111,300	146,900	222,700	0	0	220,400	334,000
Inventory	0	0	170,400	397,700	170,400	397,700	170,400	397,700	511,300	1,193,100
Accounts receivable	0	0	233,900	506,700	233,900	506,700	233,900	506,700	701,600	1,520,200
Contingency	70,600	59,700	100,000	100,000	150,000	250,000	250,000	350,000	570,600	759,700
Net investment	390,100	379,200	4,292,600	5,634,000	6,646,600	8,685,300	654,300	1,254,400	11,983,600	15,952,900

[1]Totals may differ from values in columns due to rounding.

FLOW OF MATERIALS

Forest products manufacturers with whom we worked in making this study said that the results would only be as good as the assumptions made about manufacturing cost. They suggested that we provide detailed information on flow of materials so that they could make their own analysis. Readers most interested in costs and conclusions may want to skip this section and pick up at the discussion of operating costs.

A computer program was developed to calculate the volume per hour of all materials flowing through a COM-PLY panel factory. First, the program computes the flow of particleboard through any size particleboard press selected for the factory. This key piece of machinery determines the flow of all other materials through the factory. Then the program computes the amounts of resin binder, catalyst required for rapid cure of resin binder, wax, and cubic feet of wood associated with the hourly flow of particleboard through the press. The program computes particleboard flow for any width and length of press; number of press openings; number of press cycles per hour; waste trimmed from the cured panels; levels of resin, catalyst and wax used; three-layer or homogeneous board; and specific gravity of the board. Table 3 lists values used in the program for Case I and Case II. In Case I, total cycle time for pressing is 6.5 minutes. For a two-stage operation, the particleboard press has a total cycle time of 4.2 minutes and the veneer-applicating press has a total cycle time of 3 minutes.

Table 3.—Amounts assumed for production variables in order to calculate flow of materials through the particleboard section of the COM-PLY panel factory

Variable	Case I	Case II[1]
	. . *Amounts* . . .	
Net width of press (feet)	4	4
Net length of press (feet)	8	24
Press openings	30	14
Press cycles per hour	9.23	14.29
Allowance for width trim (feet)	.33	.33
Allowance for length trim (feet)	.67	.67
Specific gravity of particleboard (percent)	.6	.6
Resin solids in particleboard (percent)	6	6
Wax solids in particleboard (percent)	.5	.5
Average specific gravity of wood supply	.59	.59

[1]Amounts shown are for the particleboard press of a two-stage operation. The hot-press for applying veneers to cores is a 4- by 8-foot by 30-opening low-pressure press and has 20 press cycles per hour.

Green-wood volumes are assumed to be 1.15 times dry-wood volumes—a value reported by Koch (1972). Table 4 lists some computed flow rates for the particleboard portion of COM-PLY panel manufacturing.

The program computes hourly flow of panels produced, veneer-laminating adhesive, veneer, peeling residues, number of peeler logs required, and Btu of fuel required to dry veneer and chips from veneer residue. After the program has calculated the hourly flow of particleboard, it computes the number of particleboard panel cores that can be cut from the particleboard. Next, the hourly dry veneer volume associated with the number of panel cores is computed. Studies (Koenigshof unpublished,[1] McAlister and Taras 1978) have been made for southern pine timber that provide ratios between dry and green veneer volumes, dry veneer and peeler log volumes, and other characteristics. These ratios provide means for correlating log veneer quantities with panel core flow. Ratios used in computations for this study (table 5) are taken from COM-PLY Report 9 (McAlister and Taras 1978). From quantities reported in tables 5 and 6, the reader can compute acres of southern pine timber required to operate a composite panel factory or evaluate other possible combinations of wood residues and veneers that might be used to make panels.

[1]Data on file U.S. Dep. Agric. For. Serv., For. Sci. Lab., Athens, Ga.

Table 4.–Some of the computed flow of materials for the particleboard operation

Material	Flow					
	Cubic feet per cycle		Cubic feet per hour		Pounds per hour	
	Case I	Case II	Case I	Case II	Case I	Case II
Particleboard pressed	28.2	37.4	259.9	534.1	9,730	19,997
Ovendried wood in particleboard					8,805	18,097
Solid ovendried wood in particleboard			239	492		
Green wood from peeling residue to be chipped					13,303	28,825
Green wood from top logs too small to peel into veneer					5,973	10,512
Resin solids in particleboard					528	1,086
Wax liquid emulsion in particleboard					92	189
Water in particleboard after pressing					352	724

Table 5.–Ratios used for computing the flow of veneer, veneer residues, and linear feet of logs through a COM-PLY panel factory[1]

Ratio	Value
Volume of dry-peeling residue to volume of dry A, B, C, and D veneer yield	0.853
Linear feet of peeler log to cubic foot of dry A, B, C, and D veneer[2]	3.32
Linear feet of small logs from upper part of tree to cubic foot of upper tree stem[2]	3.7
Volume of green peeler log to volume of dry A, B, C, and D veneer	2.22

[1] From McAlister and Taras (1978).
[2] From unpublished studies by G. A. Koenigshof on file at the U.S. Dep. Agric. For. Serv., For. Sci. Lab., Athens, Ga.

One input variable to the program is the moisture content of the green peeler blocks. After the hourly volume of green peeler logs required to operate the factory has been determined, the program computes the amount of water removed during drying of veneer and veneer-peeling residues. Then the program computes the Btu of energy required to remove the water from veneer and veneer-peeling residues. It is assumed that 1,500 Btu are required to remove 1 pound of water from 1/10-inch-thick green veneer, and 1,800 Btu are required to remove 1 pound of water

Table 6.—Average dry volume of veneer and residues per acre in a typical, natural stand of southern pine[1]

Item	Yield per acre	Proportion of total stand volume per acre
	Cubic feet	*Percent*
A & B veneer	121.5	9.0
C veneer	291.1	21.5
D veneer	182.1	13.5
Total full-length veneer	594.7	44.0
Fishtail	43.6	3.2
Total veneer	638.3	47.2
Peeling residue	507.5	37.6
Total block volume	1,145.8	84.8
Top log residue	205.8	15.2
Total-tree volume	1,351.6	100.0

[1]From McAlister and Taras (1978). Based on per-acre values for number of trees, block volume, and tree volume in a typical, natural stand of southern pine.

from green wood chips.

Table 7 lists hourly volume flows for panel cores, veneer, veneer logs, peeling residues, water removed to dry wood, and other quantities that are necessary to select equipment and determine operating costs.

The number of panels laminated each hour depends on the number of panel cores coming from the particleboard press. The number of panel cores produced per hour, therefore, determines the veneer and veneer log requirements, shown in table 7.

The program computes the quantities of adhesive required for laminating veneer to cores. Amount of glue spread on the veneers and particleboard can be varied in the computer program. In our study, the laminating adhesive spread between the core and the veneer was 20 lb/Mft^2 of glueline for a single-stage operation. The adhesive spread between the veneer and the particleboard core was 40 lb/Mft^2 of glueline for a two-stage operation. Table 7 shows hourly amounts of laminating adhesive used for Case I and Case II.

OPERATING COSTS

Operating costs are major determinants of annual net earnings or cash proceeds from the investment. It is emphasized that the operating costs reported here are based on 1975 price levels. In this study, it is assumed that the factory operates 6 days per week and 50 weeks per year. Out of each 24-hour day, it is assumed that there are 22 hours of useful work. Efficiency is thus about 92 percent, or 6,600 hours of production per year. Such high efficiency is possible because only a single item is being made and the setup and startup times are small. Normally, plants that make a variety of particleboards have efficiencies of about 85 percent.

Table 7.—Hourly flows of veneer, veneer logs, panel cores, peeling residues and laminating glue requirements

Material	Amounts per hour	
	Case I	Case II
Panel cores produced (number)	277	600
Dry veneer required for panels including 16 percent waste (square feet)	20,557	44,544
Dry veneer required (cubic feet)	171	371
Green veneer logs required (cubic feet)	380	823
Green logs to be barked (linear feet)	569	1,233
8-foot peeler blocks to be peeled (number)	67	145
Peeling residues produced from cores, roundup and spur trim (cubic feet)	168	364
Green wood required in addition to peeling residues to supply wood particles for particleboard cores (assumed to come from tops of trees above height where peeler blocks occur) (cubic feet)	75	133
Small logs from upper tree stems to be barked for wood particles (linear feet)	279	491
12-foot-long small logs to be barked (number)	32	60
Water removed from green veneer during drying (pounds)	7,254	15,718
Water removed from green wood chips during drying (pounds)	8,966	19,427
Phenol-resorcinol laminating adhesive (resin plus catalyst) for gluing veneer to particleboard core (mixed liquid pounds)	408	1,766

Unit Materials Cost

Wood

Manufacturers of COM-PLY panels would have several potential sources of wood. They could purchase veneer of the grade required for panels and the lowest cost mill residue available for the wood particles in the particleboard. They could purchase tree-length timber, peel veneer of the quality needed from that portion of the tree with a nominal diameter of 8 inches or larger, and convert the peeling residues and portions of the tree too small to peel into wood particles for the particleboard. We have used the second method in this study. Purchasing tree-length timber has distinct advantages which offset its disadvantages.

One advantage of using tree-length timber is that parts of the tree which are too small to peel, as well as the peeling residues from the veneer operation (cores, roundup, spur-trim), can be converted into clean chips of higher quality than mill residues typically used to make particleboard. Practically no waste is generated from such a wood supply. In this study, we assumed that 5 percent waste and scrap would be lost during the particle-chipping operation. Wood residues generated from trimming veneer into 4-foot widths and panel trimming are assumed to be used in the particleboard core. Veneer losses during manufacture are assumed to be 16 percent in computing veneer requirements, but almost all of the lost veneer can be converted into wood particles for the core.

The most important advantage to using full-length trees is that wood particles of optimum size and shape can be made from peeling residues and those parts of the tree too small to peel into veneer. Particles made by chipping roundwood and then milling the chips into flakes are ideal for COM-PLY panels. Much less resin is required to coat

large flakes (up to 2 inches long) than to coat particles made from sawmill residues, which typically contain a large percentage of fine material. Although more energy is required to dry flakes and splinters made from green wood than to dry sawmill residues, this higher cost is more than offset by the reduced amounts of waste, scrap wood, and resin.

In 1975, southern pine saw logs cost about $117.25/M board feet (Doyle scale) delivered to the mill (U.S. Dep. Agric. 1977). When converted to cost per green cubic foot, this price is approximately $0.53 for southern pine. Tree-length logs could probably be obtained at less cost per cubic foot because the material in tops is worth less and because harvesting and hauling costs would be somewhat less than for saw logs. COM-PLY panels do not require peeler logs of the quality required to make plywood. Peeler logs as used to make plywood could cost as much as 50 percent more than saw logs. In this study, we assume that green wood for COM-PLY panels would have cost $0.53 per cubic foot in 1975. Since wood shrinks about 15 percent when dried and we assume that 5 percent is wasted in the factory, the cost of dry wood in the panel is about $0.64 per cubic foot when green wood costing $0.53 per cubic foot is used. For the 10-year-investment period in this study, costs of green wood were assumed to increase at a compound rate of 5 percent per year, as tabulated below:

Yearly period	Cost of green wood (dollars/cubic foot)
1	0.530
2	0.557
3	0.584
4	0.614
5	0.644
6	0.676
7	0.710
8	0.746
9	0.783
10	0.822

The volume of veneer in a 1/2-inch-thick COM-PLY panel is about 40 percent of the panel volume, whereas the volume of A, B, C, and D veneer in an average mixture of southern pine trees is over 44 percent of the tree volume (see table 6). Tree-length southern pine timber, therefore, contains just about the right amount of veneer for panel manufacturing. In this process, nearly complete tree utilization is achieved.

High-quality timber is not required for making veneer for COM-PLY panels. Studies on grade and yield for southern pine indicate that COM-PLY panels can be made from veneer in No. 2 saw logs.

Potential manufacturers of COM-PLY panels must consider all the factors discussed and select a low-cost wood supply of their own for analysis of economic feasibility. However, the quality of the COM-PLY panel with regard to durability and dimensional stability is greatly influenced by the type of wood selected to make the flakes for the core. Therefore, performance as well as cost must be considered when determining the type and cost of wood.

Particleboard Phenolic Resin Binder

The source of wood for panels influences the amount of resin required in cores, and resin cost is a major expense. Figure 2 shows industrial average prices for the phenolic resin used in particleboard on a 100 percent solids basis. From 1955 to 1973, the price of phenolic resins steadily declined; then in 1974 the price rose drastically as a result of shortages of petrochemicals. This study is based on the 1975 price of $0.31 per pound for phenolic resin, and we estimated price increase at a compound rate of 5 percent per year.

Particleboard Wax

Liquid wax emulsions are added to particleboard in order to reduce thickness swelling when the particleboard is soaked in water for short periods. These emulsions, roughly half wax solids, were priced at $0.08 per liquid pound in 1975. In this study, we used this 1975 price for wax emulsion and assumed it would increase at a compound rate of 5 percent per year.

Figure 2.–Price of phenolic resin per dry pound on a 100 percent solids basis.

Laminating Adhesive

Phenolic adhesives are widely used for laminating veneers in plywood. Cost of these adhesives when mixed was about $0.127 per liquid pound in 1975, and we estimated price increase at a compound rate of 5 percent per year.

Total Materials Cost

Total annual cost for materials was estimated by multiplying the quantity of materials flowing per hour times 6,600 hours per year times the unit price of the materials (see table 8).

Labor Cost

Labor costs, which have been rising rapidly since 1961, vary with skills required, fringe benefits, and geographic locations.

Table 9 was developed from industry reviews to show our projected wages in a plant in Arkansas for various levels of skill from 1975 through 1985. We assumed that wages, including fringe benefits, would be at the prevailing rates in that State. Tables 10 and 11 list all of the job descriptions, number of workers, number of shifts worked, wage rates paid, hours worked per day, and daily labor cost for each operation for Case I and Case II. Total daily labor cost was calculated to be $4,407.28 for Case I and $6,680.56 for Case II. This sum multiplied by the 300 days worked per year is the total annual labor cost. At full production capacity, the annual labor cost at the 1975 rate is $1,322,184 for Case I and $2,004,168 for Case II.

The annual cost for labor escalates exponentially from year to year, as indicated by the growth rate in table 9. Of course, the amount of labor required during the beginning years will be less than when the plant reaches full production. In fact, during the first-year construction period (1975), there will be no direct labor cost.

Table 8.–Annual cost of materials for a COM-PLY panel factory for Case I and Case II

Item and Case	Flow of materials per hour		Time worked per year		Unit price		Total annual cost
			Hours		..... *Dollars*		
Case I							
Wood (green-tree length)	455.0 ft^3	X	6,600	X	0.530	=	1,591,590
Flakeboard resin	528.0 lb (dry)	X	6,600	X	.310	=	1,080,288
Flakeboard wax	91.7 lb (liquid)	X	6,600	X	.080	=	48,418
Laminating adhesive	407.6 lb (liquid)	X	6,600	X	.127	=	341,650
Total							3,061,946
Case II							
Wood (green-tree length)	955.5 ft^3	X	6,600	X	.530	=	3,342,339
Flakeboard resin	1,085.8 lb (dry)	X	6,600	X	.310	=	2,221,547
Flakeboard wax	188.9 lb (liquid)	X	6,600	X	.080	=	99,739
Laminating adhesive	1,766.4 lb (liquid)	X	6,600	X	.127	=	1,480,596
Total							7,144,221

Table 9.–Estimated labor wages (including fringe benefits) for operating a COM-PLY panel factory in Arkansas from 1975 through 1985[1]

Year	Skill level of workers		
	Skilled	Semiskilled	Unskilled
	..... *Dollars per hour*		
1975	4.96	4.54	4.02
1976	5.23	4.78	4.24
1977	5.51	5.05	4.47
1978	5.81	5.32	4.71
1979	6.13	5.61	4.97
1980	6.46	5.92	5.24
1981	6.82	6.24	5.52
1982	7.19	6.58	5.82
1983	7.58	6.94	6.14
1984	7.99	7.31	6.47
1985	8.42	7.71	6.83

[1] Wages escalate by the amount $10^{0.023(n-1)}$ where n is 1 to 11 for years 1975 through 1985.

Table 10.—Labor requirements for COM-PLY panel factory (Case I)

Operations or job	Workers	Shifts	Hourly wage rate[1]	Time worked per day	Daily cost for labor
	. . . *No*		*Dollars*	*Hours*	*Dollars*
Log scaler	1	1	4.96	8	39.68
Log-lift driver	2	1	4.54	16	72.64
Barker operator	1	1	4.54	8	36.32
Conveyor chaser	1	1	4.02	8	32.16
Fireman	1	4	4.54	32	145.28
Cutoff sawyer	1	1	4.54	8	36.32
Helper	1	1	4.02	8	32.16
Log sorter	1	1	4.96	8	39.68
Jitney driver (veneer log)	1	1	4.54	8	36.32
Grinding-room man	1	1	4.96	8	39.68
Lathe operator	1	1	4.96	8	39.68
Lathe spotter	1	1	4.54	8	36.32
Clipperman (green)	2	1	4.54	16	72.64
Offbearer	6	1	4.02	48	192.96
Jitney driver (veneer)	1	3	4.54	24	108.96
Dryer tender	1	3	4.54	24	108.96
Dryer feeder	2	3	4.02	48	192.96
Dryer offbearer	4	3	4.02	96	385.92
Glue mixer	1	1	4.54	8	36.32
Veneer plugger	1	3	4.02	24	96.48
Jointer & edge gluer	2	1	4.02	16	64.32
Layup	2	3	4.54	48	217.92
Press operator	2	3	4.54	48	217.92
Jitney driver (warehouse)	2	3	4.54	48	217.92
Panel sawyer	1	1	4.54	8	36.32
Strapper operator	1	1	4.02	8	32.16
Car loader	2	1	4.54	16	72.64
Splitter & slasher	1	1	4.54	8	36.32
Chipper operator	1	1	4.54	8	36.32
Cleanup (screen)	1	1	4.02	8	32.16
Hammermill operator	1	3	4.54	24	108.96
Dryer & screen operator	1	3	4.54	24	108.96
Resin mixer	1	3	4.54	24	108.96
Former operator	1	3	4.96	24	119.04
Trimmer & cooler	1	3	4.54	24	108.96
Millwright	1	3	4.96	24	119.04
Millwright helper	1	3	4.54	24	108.96
Electrician	1	3	4.96	24	119.04
Cleanup	1	3	4.02	24	96.48
Foreman	1	3	6.25	24	150.00
Superintendent	1	1	10.00	8	80.00
Machinist	1	1	4.96	8	39.68
Pipefitter	1	1	4.96	8	39.68
Storeroom man	1	1	4.54	8	36.32
Watchman	1	3	4.02	24	96.48
Shipping clerk	1	1	4.54	8	36.32
Office clerk	1	1	4.54	8	36.32
Sanderman	1	1	4.96	8	39.68
Grader	1	1	4.54	8	36.32
Patcher	2	1	4.54	16	72.64
Total				976	4,407.28

[1] Hourly rate includes 25 percent for taxes and fringe benefits.

Table 11.–Labor requirements for COM-PLY panel factory (Case II)

Operations or job	Workers	Shifts	Hourly wage rate[1]	Time worked per day	Daily cost for labor
	. . . *No*		*Dollars*	*Hours*	*Dollars*
Log scaler	1	2	4.96	16	79.36
Log-lift driver	4	2	4.54	64	290.56
Barker operator	1	2	4.54	16	72.64
Conveyor chaser	1	2	4.02	16	64.32
Fireman	1	4	4.54	32	145.28
Cutoff sawyer	1	2	4.54	16	72.64
Helper	1	2	4.02	16	64.32
Log sorter	1	2	4.96	16	79.36
Jitney driver (veneer log)	1	2	4.54	16	72.64
Grinding-room man	1	1	4.96	8	39.68
Lathe operator	1	2	4.96	16	79.36
Lathe spotter	1	2	4.54	16	72.64
Clipperman (green)	2	2	4.54	32	145.28
Offbearer (veneer)	6	2	4.02	96	385.92
Jitney driver (veneer)	1	3	4.54	24	108.96
Dryer tender	1	3	4.54	24	108.96
Dryer feeder	4	3	4.02	96	385.92
Dryer offbearer	8	3	4.02	192	771.84
Glue mixer	1	1	4.54	8	36.32
Veneer plugger	2	3	4.02	48	192.96
Jointer & edge gluer	2	2	4.02	32	128.64
Layup	4	3	4.54	96	435.84
Press operator	2	3	4.54	48	217.92
Jitney driver (warehouse)	2	3	4.54	48	217.92
Panel sawyer	1	2	4.54	16	72.64
Strapper operator	1	2	4.02	16	64.32
Car loader	2	2	4.54	32	145.28
Splitter & slasher	1	2	4.54	16	72.64
Chipper operator	1	2	4.54	16	72.64
Cleanup (screen)	1	2	4.02	16	64.32
Hammermill operator	1	3	4.54	24	108.96
Dryer & screen operator	1	3	4.54	24	108.96
Resin mixer	1	3	4.54	24	108.96
Former operator	1	3	4.96	24	119.04
Trimmer & cooler	1	3	4.54	24	108.96
Millwright	1	3	4.96	24	119.04
Millwright helper	1	3	4.54	24	108.96
Electrician	1	3	4.96	24	119.04
Cleanup	1	3	4.02	24	96.48
Foreman	1	3	6.25	24	150.00
Superintendent	1	1	10.00	8	80.00
Machinist	1	1	4.96	8	39.68
Pipefitter	1	1	4.96	8	39.68
Storeroom man	1	1	4.54	8	36.32
Watchman	1	3	4.02	24	96.48
Shipping clerk	1	1	4.54	8	36.32
Office clerk	1	1	4.54	8	36.32
Sanderman	1	2	4.96	16	79.36
Grader	1	2	4.54	16	72.64
Patcher	2	2	4.54	32	145.28
Press operator	1	3	4.54	24	108.96
Total				1,504	6,680.56

[1] Hourly rate includes 25 percent for taxes and fringe benefits.

Energy Cost

A COM-PLY panel factory requires two types of energy for its operation—electrical to power motors in machinery and thermal to dry wet wood. Some operations require both electrical and thermal energy, while others require only one. Actual energy costs depend on the volume of materials being processed, efficiency of the machinery, fuel type, and fuel costs.

Table 12 lists the major energy-using operations in a COM-PLY panel factory and shows the estimated quantities of electrical and thermal energy for a given production unit per hour. For example, table 12 shows that drying chips requires 18 kilowatt-hours of electrical energy for every green ton of chips processed and 1,800 Btu of thermal energy for every pound of water removed from the chips. The values for energy shown in table 12 are estimates; actual values in a factory could vary widely, depending on machine efficiency.

Tables 13 and 14 show the energy computations for Case I and Case II. For example, the amount of green wood to be chipped and dried for Case I (from table 4) is 13,303 pounds per hour of residues and 5,973 pounds per hour of small top logs. The total is 19,276 pounds per hour or 9.6 tons per hour. The estimated electrical energy required for drying chips is 18 kilowatt-hours per green ton (from table 12) times 9.6 green tons per hour, or 172.8 kilowatt-hours per hour. For Case I, table 7 shows the amount of water removed from green chips is 8,966 pounds per hour. The estimated thermal energy required to dry the green chips is obtained by multiplying 8,966 pounds of water per hour times 1,800 Btu per pound of water removed or 16,138,800 Btu per hour. The values for electrical energy are based on full-rated horsepower of motor-driven equipment and must be reduced to 70 percent of the values shown in order to be more realistic about actual loads on the motors. For electricity costing $0.014 per kilowatt-hour, the cost per year for electricity is $95,592; for thermal energy costing $0.07 per therm, the cost per year is $145,649. The total energy cost per year for Case I is $241,241 in 1975. The annual energy cost for Case II is $206,306 for electrical energy and $325,663 for thermal fuel or a total energy cost of $531,969 in 1975. In this study, the price of fuel increases at a compound rate of 5 percent per year.

Other Production Costs

There are various other costs associated with manufacture that need to be accounted for in operating a factory. These costs are best obtained from accounting records of an actual factory; the amounts shown in table 15 are rough estimates.

Sales promotion expenses were arbitrarily assumed to be 6 percent of the 1975 sales if the plant had been operating at full capacity. These expenses were distributed over the first 3 years of operation in declining amounts of 3 percent, 2 percent, and 1 percent.

Depreciation

Depreciation must be computed in order to determine the manufacturing costs, taxable income, and return on investment. We used the straight-line method of depreciation to determine manufacturing cost and the sum-of-the-years digit method to determine return on investment.

ANNUAL SALES, OPERATING CASH FLOWS, AND TOTAL MANUFACTURING COST

This section shows the cash proceeds or net earnings that accrue from the manufacturing operation. In computing net earnings, we estimated revenue from sales and then subtracted manufacturing costs and taxes.

Some price has to be assumed for the product. In this analysis, therefore, the prices of COM-PLY panels are assumed to equal those of A-B sanded and C-D unsanded exterior grades of plywood.

It is extremely difficult to accurately predict panel prices because they fluctuate widely with economic conditions. The average f.o.b. mill price of 1/2-inch-thick Standard Exterior southern pine plywood was $75.50/Mft^2 in 1970 and rose to $162.67/Mft^2 in 1976 (Evans 1976). Average price for the 6-year period was $136.36/Mft^2. This rise in price equals compound growth rate of about 14 percent for a 6-year period. In 1975, the average f.o.b. mill price for 1/2-inch-thick Standard Exterior southern pine plywood was $122.00/Mft^2. The year 1975 was a period of recession, low home-building activity, and low plywood prices. We therefore estimated that COM-PLY panel prices would increase at a compound growth rate of 5 percent during the investment period from 1975 to 1985. Table 16 shows expected f.o.b. mill prices for COM-PLY 1/2-inch-thick A-B sanded and C-D unsanded exterior-grade COM-PLY panels.

Table 12.–Energy required to make COM-PLY panels

Production operations	Production units per hour	Electrical energy per unit	Thermal energy per unit
		kWh	*Btu*
Barking logs	Linear feet of logs	0.004 to 0.012	–
Hogging waste wood and bark	Green tons	20 to 40	–
Conveying chips, logs, etc.	Green tons	35	–
Steaming peeler blocks	Green tons	–	110,000
Log cutoff and slasher saws	Linear feet of logs	0.002	–
Log-sorting deck equipment	Linear feet of logs	0.003	–
Peeling veneer blocks on rotary lathe	Square feet of veneer	0.006	–
Veneer drying			
a. electrical	Square feet of veneer	0.007	–
b. thermal	Pounds of water removed	–	1,500
Conveying veneer	Square feet of veneer	0.003	–
Patching panels	Square feet of panels	0.001	–
Chipping round and waste wood into chips	Green tons of wood	17 to 40	–
Hammermilling chips into particles	Green tons of chips	15 to 25	–
Drying chips			
a. electrical	Green tons	18	–
b. thermal	Pounds of water removed	–	1,800
Screening chips	Dry tons of chips	0.3 to 0.5	–
Blending particles with resin and resin mixing	Dry tons of particles	8	–
Forming particleboard matt	Dry tons of matt	5	–
Prepress matt	Square feet of matt	0.004	–
Press matt into particleboard			
a. electrical	Dry tons of matt	6	–
b. thermal			
(1) heat matt	Dry tons of matt	–	120,000 to 160,000
(2) heat cauls (if used)	Dry tons of matt	–	80,000 to 160,000
(3) heat losses			
(a) water evaporation	Dry tons of matt	–	80,000 to 160,000
(b) radiation	Dry tons of matt	–	6,000 to 12,000
(c) convection	Dry tons of matt	–	4,000 to 12,000
Finish panels	Square feet of panels	0.004	–
Press panels to apply veneer			
a. electrical			
(1) press and prepress panels	Dry tons of panels	6	–
b. thermal			
(1) heat panels to cure glue	Dry tons of panels	–	100,000 to 140,000
(2) heat cauls	Dry tons of panels	–	80,000 to 160,000
(3) heat losses			
(a) water evaporation	Dry tons of panels	–	80,000 to 160,000
(b) radiation	Dry tons of panels	–	6,000 to 12,000
(c) convection	Dry tons of panels	–	4,000 to 12,000

Table 13.–Estimated energy required per hour to produce COM-PLY panels for Case I[1]

Operation	Energy unit		Materials unit		Energy/hour[2] Electrical	Energy/hour[2] Thermal
					kWh	*Btu*
Barking logs	0.006	X	848.0	=	5.09	
Hogging fuel	30.000	X	1.8	=	54.00	
Conveying chips	35.000	X	9.6	=	336.00	
Steaming blocks	110,000.000	X	15.0	=		1,650,000
Log cutoff	.002	X	848.0	=	1.70	
Log sorting	.003	X	848.0	=	2.54	
Peeling veneer	.006	X	20,557.0	=	123.34	
Veneer drying	.007	X	20,557.0	=	143.90	
Veneer drying	1,500.000	X	7,254.0	=		10,881,000
Conveying veneer	.003	X	20,557.0	=	61.67	
Patching panels	.001	X	8,861.0	=	8.86	
Flaking wood	26.000	X	9.6	=	249.60	
Hammermilling	20.000	X	9.6	=	192.00	
Drying chips	18.000	X	9.6	=	172.80	
Drying chips	1,800.000	X	8,966.0	=		16,138,800
Screening chips	.400	X	4.4	=	1.76	
Blending	8.000	X	4.4	=	35.20	
Forming matt	5.000	X	4.9	=	24.50	
Prepress matt	.004	X	32.0	=	.13	
Pressing matt	6.000	X	4.9	=	29.40	
Heating matt	160,000.000	X	8.0	=		1,280,000
Heating cauls	100,000.000	X	8.0	=		800,000
Water loss	80,000.000	X	8.0	=		640,000
Radiation loss	9,000.000	X	8.0	=		72,000
Convection loss	8,000.000	X	8.0	=		64,000
Finish panels	.004	X	8,861.0	=	35.44	
					1,477.93	31,525,000
					X .70[3]	
					1,034.55	

[1] Factory is assumed to work 6,600 hours per year. Hourly totals for kWh and Btu must be multiplied by this value to obtain yearly totals.

[2] Data may not equal totals due to rounding and truncating.

[3] Electrical energy is 70 percent of total in order to account for motors not running at full-rated horsepower.

Table 14.–Estimated energy required per hour to produce COM-PLY panels for Case II[1]

Operation	Energy unit		Materials unit		Energy/hour[2] Electrical	Energy/hour[2] Thermal
					kWh	*Btu*
Barking logs	0.006	X	1,734.0	=	10.40	
Hogging fuel	30.000	X	3.8	=	114.00	
Conveying chips	35.000	X	19.7	=	689.50	
Steaming blocks	110,000.000	X	32.6	=		3,585,999
Log cutoff	.002	X	1,734.0	=	3.47	
Log sorting	.003	X	1,734.0	=	5.20	
Peeling veneer	.006	X	44,544.0	=	267.26	
Veneer drying	.007	X	44,544.0	=	311.81	
Veneer drying	1,500.000	X	15,718.0	=		23,577,000
Conveying veneer	.003	X	44,544.0	=	133.63	
Patching panels	.001	X	19,200.0	=	19.20	
Chipping wood	26.000	X	19.7	=	512.20	
Hammermilling	20.000	X	19.7	=	394.00	
Drying chips	18.000	X	19.7	=	354.60	
Drying chips	1,800.000	X	19,427.0	=		34,968,600
Screening chips	.400	X	9.2	=	3.68	
Blending	8.000	X	9.2	=	73.60	
Forming matt	5.000	X	10.5	=	52.50	
Prepress matt	.004	X	96.0	=	.38	
Pressing matt	6.000	X	10.5	=	63.00	
Heating matt	140,000.000	X	10.5	=		1,470,000
Heating cauls	100,000.000	X	10.5	=		1,050,000
Water loss	80,000.000	X	10.5	=		840,000
Radiation loss	9,000.000	X	10.5	=		94,500
Convection loss	8,000.000	X	10.5	=		84,000
Finish panels	.004	X	19,200.0	=	76.80	
Press veneer	6.000	X	17.4	=	104.40	
Heat veneer	120,000.000	X	17.4	=		2,087,999
Heat cauls	120,000.000	X	17.4	=		2,087,999
Water loss	20,000.000	X	17.4	=		347,999
Radiation loss	9,000.000	X	17.4	=		156,599
Convection loss	8,000.000	X	17.4	=		139,199
					3,189.64	70,489,999
					X .70[3]	
					2,232.75	

[1] Factory is assumed to work 6,600 hours per year. Hourly totals for kWh and Btu must be multiplied by this value to obtain yearly totals.

[2] Data may not equal totals due to rounding and truncating.

[3] Electrical energy is 70 percent of total in order to account for motors not running at full-rated horsepower.

Table 15.–Miscellaneous production costs in operating a COM-PLY panel factory

Cost	Amount		
	Percent of sales	Percent of land, building, and facilities cost	Salary (in 1975)
			Dollars
Production supplies	2.0		
Maintenance supplies	1.0		
Utilities	.1		
General manager			25,000
Office manager			18,000
Office clerks (three at $6,000 each)			18,000
Grade-certification fees	1.0		
Other office administrative expenses	.5		
Facilities maintenance		2.0	
Facilities taxes		.5	
Facilities insurance		.5	
Sales expense	5.0		
Contingency expense	2.0		

Table 16.–Estimated f.o.b. mill prices for 1/2-inch-thick A-B sanded and C-D unsanded exterior-grade COM-PLY panels during the investment period from 1975 to 1985

Year	Price	
	A-B grade	C-D grade
	. . . . . *Dollars per M board feet*	
1975	231.80	122.00
1976	243.39	128.10
1977	255.56	134.51
1978	268.34	141.23
1979	281.75	148.29
1980	295.84	155.71
1981	310.63	163.49
1982	326.17	171.67
1983	342.47	180.25
1984	359.60	189.26
1985	377.58	198.73

The price of sanded A-B exterior-grade panels was essentially twice that of unsanded C-D exterior-grade panels in May of 1976. The price of sanded A-B exterior-grade panels seems to fluctuate between 1.8 and 2.0 times that of unsanded C-D exterior-grade panels. This study assumed that the price for sanded A-B panels will be 1.9 times that for unsanded C-D panels.

Tables 17 and 18 show the annual cash flows from operating a COM-PLY panel factory over the 10-year period for Case I and Case II. In this study, it is assumed that the production level of panels will be zero during the first year of the investment because of plant construction, 20 percent the second year, 80 percent the third year, and 100 percent the fourth year. When the factory reaches 100 percent production, it will be operating at an efficiency of 92 percent.

The cash flows from sales in tables 17 and 18 were computed by multiplying the f.o.b. mill price times the square footage of panels produced per year. The volume of panels for Case I is 276.9 4- by 8-foot panels per hour, or 58,481,280 square feet per year. From table 16, the sales price in 1975 is $122/Mft^2 for C-D grade panels and $231.80/Mft^2 for A-B grade panels. In table 6 it is shown that the quantity of veneer available from southern pine stands is approximately 20 percent A and B grades and 80 percent C and D grades. Therefore, the mix of panel grades used in this study is assumed to be 20 percent A-B panels and 80 percent C-D panels. All are assumed to contain exterior resin binder in the particleboard and in the veneer-to-particleboard glueline. The yearly quantity of A-B exterior-grade panels produced is 11,696 M square feet; that of C-D exterior panels is 46,785 M square feet. To illustrate method used, sales for the first 4 years are computed in table 19 only for Case I.

Buildings, facilities, and machinery have some terminal salvage value at the end of the 10-year-investment period. Because terminal salvage is revenue from a sale and is taxable, it is treated as a sales item during the last year of the investment period.

Computing the cash flows for operating costs in tables 17 and 18 is similar to computing the cash flows for sales. The inflation rate used was 5 percent except for wage rates, which escalated at the rate shown in table 9. The general manager, office manager, and clerks were assumed to be hired on a full-time basis at the beginning of the second year. Sales promotion occurred only during the first 3 years, declining from $252,600 the first year to $84,200 in the third year. Only 50 percent of the expense for facilities was assumed to occur the first year, but the entire expense occurred in subsequent years and escalated at a rate of 5 percent.

Total operating costs for tax computations were found by totaling the costs for raw materials, production, administration, sales promotion, facilities, contingencies, sales, and depreciation. For example, the operating cost for Case I in the fourth year, when full production is reached, is shown as $8,091,700. Depreciation is included with the operating cost because the Internal Revenue Service allows depreciation to be deducted as an expense for tax computations. Depreciation began in the second year, when most of the investment for machinery and facilities had been made.

The taxable income is the difference between sales and total operating cost, including depreciation. For the fourth year, the taxable income is $1,654,300. For this study, we assumed a Federal tax rate of 48 percent and additional state and local tax charges of 4 percent for a total tax rate of 52 percent. Tax on income for the fourth year is $860,200 and after-tax profit is $794,100.

To obtain the net annual earnings for the fourth year, the depreciation (which was subtracted as a production cost for computing taxes) is added back to the after-tax profit. The net earnings for the fourth year are $2,199,200.

Notice that a negative income tax is shown for the first and second years. The Federal Government does not make tax refunds to companies that have a loss from operating. However, a large company could charge off these losses against other parts of the business that were operating profitably; therefore, they have been left in this analysis. For a company that could not write off the losses that occur during the first 2 years, there would be zero income tax and negative net earnings for both years.

Operating costs shown in tables 17 and 18 can be used to compute the 1975 manufacturing cost of a panel. This cost is computed by discounting the amount for each item during the fourth year back to the 1975 cost. For most items, the 1975 price is obtained by multiplying 0.8638 times the 1978 value to account for a 5 percent annual compound increase in prices. However, change in labor costs is somewhat higher, and its multiplier is 0.8531 times the 1978 cost. Total expense for sales promotion was averaged for the 10 years to give an average yearly cost for 1975. Straight-line depreciation for a 10-year period was used for computing depreciation cost for 1975. After making these adjustments, the 1975 values were divided by 58,481,280 square feet of panels produced per year to obtain the cost per thousand square feet. Table 20 shows the 1975 estimated manufacturing cost for COM-PLY panels made in Arkansas for Case I and Case II.

Computing the operating cost shown in tables 17 and 18 is difficult, and accurate data are not easily obtained.

Table 17.–Ten-year cash flow from operations of a COM-PLY panel factory (Case I)[1]

Item	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
	Thousands of dollars									
A. Sales										
Panels (A–B exterior)	0	569.4	2,391.3	3,138.5	3,295.5	3,460.2	3,633.3	3,814.9	4,005.7	4,205.9
Panels (C–D exterior)	0	1,198.6	5,034.3	6,607.5	6,937.8	7,284.7	7,649.0	8,031.4	8,433.0	8,854.6
Terminal salvage	0	0	0	0	0	0	0	0	0	175.6
Total	0	1,768.0	7,425.5	9,746.0	10,233.3	10,745.0	11,282.2	11,846.3	12,438.6	13,236.2
B. Raw materials										
Logs	0	334.2	1,403.8	1,842.5	1,934.6	2,031.3	2,132.9	2,239.5	2,351.5	2,469.1
Particleboard resin	0	226.9	952.8	1,250.6	1,313.1	1,378.8	1,447.7	1,520.1	1,596.1	1,675.9
Particleboard catalyst	0	0	0	0	0	0	0	0	0	0
Particleboard wax	0	10.2	42.7	56.0	58.9	61.8	64.9	68.1	71.5	75.1
Laminating adhesive	0	71.7	301.3	395.5	415.3	436.0	457.8	480.7	504.8	530.0
Total	0	643.0	2,700.6	3,544.6	3,721.8	3,907.9	4,103.3	4,308.5	4,523.9	4,750.1
C. Production expense										
Direct labor	0	697.0	1,469.9	1,549.9	1,634.1	1,723.0	1,816.7	1,915.5	2,019.7	2,129.6
Power and fuel	0	50.7	212.8	279.3	293.2	307.9	323.3	339.5	356.4	374.2
Production supplies	0	35.4	148.5	194.9	204.7	214.9	225.6	236.9	248.8	261.2
Maintenance supplies	0	17.7	74.3	97.5	102.3	107.4	112.8	118.5	124.4	130.6
Utilities	0	1.8	7.4	9.7	10.2	10.7	11.3	11.8	12.4	13.1
Total	0	802.5	1,912.9	2,131.3	2,244.6	2,364.0	2,489.8	2,622.2	2,761.7	2,908.7
D. Administrative expenses										
General manager	0	26.2	27.6	28.9	30.4	31.9	33.5	35.2	36.9	38.8
Office manager	0	18.9	19.8	20.8	21.9	23.0	24.1	25.3	26.6	27.9
Clerks (3)	0	18.9	19.8	20.8	21.9	23.0	24.1	25.3	26.6	27.9
Grade-certification fees	0	17.7	74.3	97.5	102.3	107.4	112.8	118.5	124.4	130.6
Other	0	8.8	37.1	48.7	51.2	53.7	56.4	59.2	62.2	65.3
Total	0	90.6	178.6	216.8	227.6	239.0	251.0	263.5	276.7	290.5
E. Sales promotion	252.6	168.4	84.2	0	0	0	0	0	0	0
F. Facility expenses										
Maintenance	32.2	67.5	70.9	74.5	78.2	82.1	86.2	90.5	95.0	99.8
Taxes	8.0	16.9	17.7	18.6	19.5	20.5	21.6	22.6	23.8	25.0
Insurance	8.0	16.9	17.7	18.6	19.5	20.5	21.6	22.6	23.8	25.0
Total	48.2	101.3	106.4	111.7	117.3	123.2	129.3	135.8	142.6	149.7
G. Contingency expenses	0	35.4	148.5	194.9	204.7	214.9	225.6	236.9	248.8	261.2
H. Sales expense	0	88.4	371.3	487.3	511.7	537.2	564.1	592.3	621.9	653.0
I. Cost of operations (B+C+D+E+F+G+H+L)	300.8	3,685.9	7,083.3	8,091.7	8,257.2	8,440.1	8,641.3	8,861.8	9,102.5	9,364.5
J. Taxable income (A–I)	-300.8	-1,918.0	342.3	1,654.3	1,976.1	2,304.9	2,640.9	2,984.5	3,336.1	3,871.7
K. Income tax (52% X J)	-156.4	-997.3	178.0	860.2	1,027.6	1,198.5	1,373.3	1,552.0	1,734.8	2,013.3
L. Depreciation										
Machinery	0	1,229.6	1,106.7	983.7	860.8	737.8	614.8	491.9	368.9	245.9
Facilities	0	526.7	474.1	421.4	368.7	316.0	263.4	210.7	158.0	105.3
Total	0	1,756.4	1,580.8	1,405.1	1,229.5	1,053.8	878.2	702.6	526.9	351.3
M. After-tax profit (J–K)	-144.4	-920.6	164.3	794.1	948.5	1,106.3	1,267.6	1,432.6	1,601.3	1,858.4
N. Net earnings (M+L)	-144.4	835.8	1,745.0	2,199.2	2,178.0	2,160.2	2,145.8	2,135.1	2,128.3	2,209.7

[1] Data may not add to totals due to rounding and truncating.

Table 18.–Ten-year cash flow from operations of a COM-PLY panel factory (Case II)[1]

Item	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
	Thousands of dollars									
A. Sales										
Panels (A-B exterior)	0	1,233.7	5,181.5	6,800.7	7,140.8	7,497.8	7,872.7	8,266.3	8,679.7	9,113.6
Panels (C-D exterior)	0	2,597.3	10,908.5	14,317.4	15,033.2	15,784.9	16,574.1	17,402.8	18,273.0	19,186.6
Terminal salvage	0	0	0	0	0	0	0	0	0	215.0
Total	0	3,830.9	16,090.0	21,118.1	22,174.0	23,282.7	24,446.8	25,669.2	26,952.6	28,515.3
B. Raw materials										
Logs	0	701.9	2,947.9	3,869.2	4,062.6	4,265.8	4,479.1	4,703.0	4,938.2	5,185.1
Particleboard resin	0	466.5	1,959.4	2,571.7	2,700.3	2,835.3	2,977.1	3,125.9	3,282.2	3,446.3
Particleboard wax	0	20.9	88.0	115.5	121.2	127.3	133.7	140.3	147.4	154.7
Laminating adhesive	0	310.9	1,305.9	1,714.0	1,799.7	1,889.7	1,984.1	2,083.3	2,187.5	2,296.9
Total	0	1,500.3	6,301.2	8,270.3	8,683.8	9,118.0	9,573.9	10,052.6	10,555.3	11,083.0
C. Production expense										
Direct labor	0	1,056.6	2,228.1	2,349.3	2,477.0	2,611.8	2,753.8	2,903.6	3,061.5	3,228.0
Power and fuel	0	111.7	469.2	615.8	646.6	678.9	712.9	748.5	786.0	825.3
Production supplies	0	76.6	321.8	422.4	443.5	465.7	488.9	513.4	539.1	566.0
Maintenance supplies	0	38.3	160.9	211.2	221.7	232.8	244.5	256.7	269.5	283.0
Utilities	0	3.8	16.1	21.1	22.2	23.3	24.4	25.7	27.0	28.3
Total	0	1,287.1	3,196.1	3,619.8	3,811.1	4,012.5	4,224.6	4,447.9	4,683.0	4,930.6
D. Administrative expenses										
General manager	0	26.2	27.6	28.9	30.4	31.9	33.5	35.2	36.9	38.8
Office manager	0	18.9	19.8	20.8	21.9	23.0	24.1	25.3	26.6	27.9
Clerks (3)	0	18.9	19.8	20.8	21.9	23.0	24.1	25.3	26.6	27.9
Grade-certification fees	0	38.3	160.9	211.2	221.7	232.8	244.5	256.7	269.5	283.0
Other	0	19.2	80.4	105.6	110.9	116.4	122.2	128.3	134.8	141.5
Total	0	121.5	308.6	387.4	406.8	427.1	448.4	470.9	494.4	519.1
E. Sales promotion	547.3	364.9	182.4	0	0	0	0	0	0	0
F. Facility expenses										
Maintenance	35.9	75.4	79.2	83.2	87.3	91.7	96.3	101.1	106.1	111.4
Taxes	9.0	18.9	19.8	20.8	21.8	22.9	24.1	25.3	26.5	27.9
Insurance	9.0	18.9	19.8	20.8	21.8	22.9	24.1	25.3	26.5	27.9
Total	53.9	113.1	118.8	124.7	131.0	137.5	144.4	151.6	159.2	167.2
G. Contingency	0	76.6	321.8	422.4	443.5	465.7	488.9	513.4	539.1	566.0
H. Sales expense	0	191.5	804.5	1,055.9	1,108.7	1,164.1	1,222.3	1,283.5	1,347.6	1,415.0
I. Cost of operations (B+C+D+E+F+G+H+L)	601.2	5,805.3	13,168.6	15,600.7	16,090.0	16,615.1	17,177.7	17,779.9	18,423.6	19,111.0
J. Taxable income (A-I)	-601.2	-1,974.3	2,921.3	5,517.4	6,084.0	6,667.6	7,269.1	7,889.3	8,529.0	9,404.3
K. Income tax (52% X J)	-312.6	-1,026.6	1,519.1	2,869.1	3,163.7	3,467.2	3,779.9	4,102.4	4,435.1	4,890.3
L. Depreciation										
Machinery	0	1,555.3	1,399.8	1,244.2	1,088.7	933.2	777.6	622.1	466.6	311.1
Facilities	0	595.0	535.5	476.0	416.5	357.0	297.5	238.0	178.5	119.0
Total	0	2,150.3	1,935.2	1,720.2	1,505.2	1,290.2	1,075.1	860.1	645.1	430.1
M. After-tax profit (J-K)	-288.6	-947.7	1,402.2	2,648.4	2,920.3	3,200.5	3,489.2	3,786.8	4,093.9	4,514.1
N. Net earnings (M+L)	-288.6	1,202.6	3,337.5	4,368.6	4,425.5	4,490.6	4,564.3	4,646.9	4,739.0	4,944.1

[1] Data may not add to totals due to rounding and truncating.

Table 19.–Sales for first 4 years for Case I

Year	Item	Annual production at 6,600 hours per year		Price f.o.b. mill		Level of production		Sales
				Dollars per M				*Thousand dollars*
1975	A-B panels	11,696,256	X	231.80	X	0	=	0
	C-D panels	46,785,024	X	122.00	X	0	=	0
Total sales								0
1976	A-B panels	11,696,260	X	243.39	X	0.2	=	569,350
	C-D panels	46,785,024	X	128.10	X	.2	=	1,198,632
Total sales								1,767,982
1977	A-B panels	11,696,256	X	255.56	X	.8	=	2,391,276
	C-D panels	46,785,024	X	134.51	X	.8	=	5,034,443
Total sales								7,425,719
1978	A-B panels	11,696,256	X	268.34	X	1.0	=	3,138,573
	C-D panels	46,785,024	X	141.23	X	1.0	=	6,607,449
Total sales								9,746,022

Table 20.–Estimated manufacturing cost in 1975 for COM-PLY panels made in Arkansas for Case I and Case II

Item	Case I		Case II	
	Annual cost adjusted to 1975 prices	Manufacturing cost	Annual cost adjusted to 1975 prices	Manufacturing cost
	Dollars	*Dollars per M board feet*	*Dollars*	*Dollars per M board feet*
Logs	1,591,590	27.22	3,342,339	26.38
Particleboard resin	1,080,288	18.47	2,221,547	17.53
Wax	48,418	.83	99,739	.79
Veneer adhesive	341,650	5.84	1,480,596	11.68
Direct labor	1,322,184	22.61	2,004,168	15.82
Power and fuel	241,241	4.13	531,969	4.20
Other production expenses	260,987	4.46	565,521	4.46
Administrative expenses	187,284	3.20	334,639	2.64
Sales promotion	50,514	.86	109,456	.86
Facilities expense	96,498	1.65	107,754	.85
Contingency	168,379	2.88	364,852	2.88
Sales expense	420,948	7.20	912,131	7.20
Depreciation	966,100	16.52	1,182,640	9.33
Total	6,776,081	115.87	13,257,351	104.62

Potential manufacturers of COM-PLY panels probably have a good source of data in their own company records. By using their own data and making computations similar to those shown in this section, manufacturers can accurately estimate the factory cost for their own company.

NET CASH FLOWS AND INTERNAL RATE OF RETURN

Potential manufacturers of COM-PLY panels want to know what return on their investment they can expect from the cash proceeds or net earnings. The return on investment is found by determining interest rates on the basis of the present-value concept. In simple terms, if we invest $100 today at 6 percent interest, the value 1 year from today is $106. The $106 is called the future sum. The future sum includes the original amount (present value) plus interest accumulated (return on investment). The $100 is analogous to investments or cash outlays to build a factory, while the $106 is analogous to cash proceeds resulting from profitable operation.

The process of computing the present value of future sums at a given interest rate is referred to as discounting. In this study, the annual cash outlays (such as payout for investments) are considered as negative future sums and annual cash proceeds (such as net earnings from profitable operation) are considered as positive future sums. The object of the analysis is to find the compound interest or discount rate at which the present value of the cash outlays equals the present value of the cash proceeds. This procedure is widely used for evaluating the economic feasibility of investments and is often referred to as a discounted cash flow analysis. The appropriate compound interest or discount rate is found by trial and error.

A low interest rate is selected and the net annual cash flows (outlays and proceeds) or future sums are converted to their present value on the basis of the rate selected. If the cumulated net annual cash flow is positive, then the present value of the cash proceeds is greater than the present value of the cash outlays for the 10 years of operation. In that case, a higher interest rate is selected and the procedure is repeated until a rate is found at which the positive present value of cash proceeds equals the negative present value of cash outlays. This interest or discount rate is called the internal rate of return.

Internal rates of return were computed for Case I and Case II by the procedure outlined. The rate for Case I was a somewhat disappointing 10.18 percent. Most manufacturing firms could probably find a less risky investment that would earn 10 percent or more. For Case II, on the other hand, the calculated rate of return is 21.56 percent, which is quite attractive.

In this era of high inflation, many manufacturing firms find that the price of investment capital is somewhere near 15 percent. That is somewhere near the amount they must pay to borrow for a new venture. Tables 21 and 22 show the cash flows for Cases I and II at a discount rate of 15 percent.

The first column in tables 21 and 22 shows the year or period of investment. Year 0 represents the beginning of year 1, but the other numbers—1 through 10—represent yearend times. The next column shows cash outlays for investment and is taken from table 2 for Case I. The values are negative because they represent cash outlays except for the value at year 10. This value represents working capital (cash, inventory, accounts receivable) that is recovered at the end of the investment period. The recovered working capital is treated as a positive nontaxable cash flow.

Column 3 is taken from the net earnings (table 17). If production operations are unprofitable, the net earnings will be negative. However, if the production operation is profitable, the net earnings are positive and represent cash proceeds.

Column 4 is the sum of columns 2 and 3 and represents net annual cash flows.

Column 5 lists the present-value factor for a 15 percent interest rate. At rates of return less than 15 percent, a company might be better off to invest elsewhere. The values in column 4 represent future sums at the end of the year indicated. By multiplying the values in column 4 by the present-value factor in column 5, the amount in column 4 is discounted (moved backward through time) to its present value (shown in column 6). For example, at the end of year 5, the net annual cash flow for Case I was $2,178,000 and the present value of annual return was $1,082,900. In other words, if we had invested $1,082,900 at time zero at a compound interest rate of 15 percent, we would have a future sum of $2,178,000 at the end of 5 years.

Column 7 shows the cumulative present values of annual cash flows in column 6. At a discount rate of 15 percent, the $11,983,600 investment in Case I would not be paid back in 10 years. The internal rate of return is 10.18 percent. In other words, if we had used present-value factors for a discount rate of 10.18 percent, the investment would have been paid back at the end of the 10th year.

The discounted cash flow analysis for Case II is shown in table 22. For Case II, at a discount rate of 15 percent, the $15,952,900 investment would be paid back in 8 years. The internal rate of return for Case II is 21.56 percent.

Table 21.—Cash flows at a 15 percent discount rate for a COM-PLY panel factory during a 10-year-investment period for Case I[1] [2]

Year	Outlay (investment)		Proceeds (net earnings)		Net annual cash flow[3]				Present value[3] At 15%	Present value[3] Annual return	Present value[3] Cumulative
	Thousands of dollars										
0	-390.1	+	0	=	-390.1	X	1.0000	=		-390.1	-390.1
1	-4,292.6	+	-144.4	=	-4,437.0	X	.8696	=		-3,858.2	-4,248.4
2	-6,646.6	+	835.8	=	-5,810.8	X	.7561	=		-4,393.8	-8,642.2
3	-654.3	+	1,745.0	=	1,090.7	X	.6575	=		717.2	-7,925.0
4	0	+	2,199.2	=	2,199.2	X	.5718	=		1,257.4	-6,667.6
5	0	+	2,178.0	=	2,178.0	X	.4972	=		1,082.9	-5,584.7
6	0	+	2,160.2	=	2,160.2	X	.4323	=		933.9	-4,650.8
7	0	+	2,145.8	=	2,145.8	X	.3759	=		806.7	-3,844.1
8	0	+	2,135.1	=	2,135.1	X	.3269	=		698.0	-3,146.2
9	0	+	2,128.3	=	2,128.3	X	.2843	=		605.0	-2,541.2
10	1,433.3	+	2,209.7	=	3,643.0	X	.2472	=		900.5	-1,640.7

[1] The investment is not repaid at a discount rate of 15 percent interest in 10 years.
[2] Internal rate of return for 10-year-investment period is 10.18 percent.
[3] Data may not equal totals due to rounding and truncating.

Table 22.—Cash flows at a 15 percent discount rate for a COM-PLY panel factory during a 10-year-investment period for Case II[1] [2]

Year	Outlay (investment)		Proceeds (net earnings)		Net annual cash flow[3]				Present value[3] At 15%	Present value[3] Annual return	Present value[3] Cumulative
	Thousands of dollars										
0	-379.2	+	0	=	-379.2	X	1.0000	=		-379.2	-379.2
1	-5,634.1	+	-288.6	=	-5,922.6	X	.8696	=		-5,150.1	-5,529.3
2	-8,685.2	+	1,202.6	=	-7,482.6	X	.7561	=		-5,658.0	-11,187.2
3	-1,254.4	+	3,337.5	=	2,083.0	X	.6575	=		1,369.6	-9,817.6
4	0	+	4,368.6	=	4,368.6	X	.5718	=		2,497.7	-7,319.9
5	0	+	4,425.5	=	4,425.5	X	.4972	=		2,200.3	-5,119.6
6	0	+	4,490.6	=	4,490.6	X	.4323	=		1,941.4	-3,178.2
7	0	+	4,564.3	=	4,564.3	X	.3759	=		1,715.9	-1,462.3
8	0	+	4,646.9	=	4,646.9	X	.3269	=		1,519.1	56.8
9	0	+	4,739.0	=	4,739.0	X	.2843	=		1,347.1	1,403.9
10	3,047.3	+	4,944.1	=	7,991.5	X	.2472	=		1,975.4	3,379.3

[1] The payback period is 7.96 years at a 15 percent discount rate.
[2] Internal rate of return for 10-year-investment period is 21.56 percent.
[3] Data may not equal totals due to rounding and truncating.

Case I requires an investment of about $12 million to produce 58,481,280 square feet of panels per year. Case II requires an investment of about $16 million and produces 126,720,000 square feet of panels per year. In other words, a 33 percent increase in investment over that required for Case I will more than double productive capacity using the Case II two-stage method.

DISCUSSION AND CONCLUSIONS

This study shows that a two-stage system for assembling composite panels yields a much higher rate of return than a one-stage system for assembling composite panels. For the two-stage system, using 1975 prices for panels and logs, the return on investment was 21.56 percent. An after-tax return on investment of 20 percent or greater is considered favorable by most manufacturers. Furthermore, this rate may be conservative. Prices for panels in 1975 were about 12 percent below the average price for panels for the years 1972 through 1976. It seems clear that manufacture of COM-PLY panels is economically feasible.

Firms that are already manufacturing particleboard and veneer might realize returns greater than 20 percent by manufacturing COM-PLY panels. The conversion investment would be less than the initial investments shown here, and positive annual cash flows would occur sooner than if a new plant were built. This approach would make sense for other reasons. So many particleboard plants have been built in recent years that there is too much productive capacity in the United States. As a result, many particleboard plants in the United States are yielding a very low internal rate of return. The earning capacity of such plants could be improved by converting them to COM-PLY panel production.

It should also be pointed out that Case II, which appears quite profitable, represents a single, arbitrarily selected combination of machinery. Some other combination might prove even more profitable. For example, a standard 40-opening plywood press might be used to apply veneer facings instead of a 30-opening press, as used in Case II. A standard 4- by 24-foot by 20-opening particleboard press would have to be used in tandem with the 40-opening plywood panel press. It appears, however, that these machines would increase volume of production by one-third for a very modest increase in investment.

Consumer demand for particleboard often peaks a year or two after the peak demand for plywood, primarily because demand for plywood is greatest during a housing boom. After a housing boom subsides, the need for plywood drops off, as it did late in 1973. Subsequently, construction of shopping centers and manufacture of furniture increase, creating a strong demand for particleboard. Therefore, a manufacturer can weather market fluctuations by producing both COM-PLY panels and particleboard in one factory. He can shift production to the product in greatest demand.

Potential manufacturers should carefully compare the manufacturing costs for COM-PLY panels (table 20) with those for manufacturing plywood. One of the greatest expenses in making conventional plywood is the cost of wood. During periods of peak demand for plywood, the prices for stumpage increase. COM-PLY panels can more completely utilize the tree, easing supply pressure during periods of peak demand. If the supply of logs within a reasonable distance from a plywood mill is insufficient, the mill can be forced to close. A plywood plant faced with a limited timber supply could convert to composite panels and continue to operate on the limited supply of logs for many years. Conversion is possible because fewer logs of lower quality are needed for COM-PLY panels. A manufacturer of COM-PLY panels has a distinct raw-materials cost advantage. Wood represents a smaller proportion of the cost of a COM-PLY panel than a plywood panel. For COM-PLY panels, the cost for resin binder, wax, and laminating adhesive is greater than for wood. These nonwood costs are more stable and changes in them normally do not coincide with changes in wood costs.

The sizes of logs available for making plywood sheathing seem certain to decline. This study shows that it is economically feasible to manufacture COM-PLY panels now. A handsome return is indicated for the investment period from 1975 to 1985. As time passes, the advantage of COM-PLY panels over conventional plywood is likely to increase.

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Keywords: Manufacturing costs, sheathing cost, economics of panel manufacture, cost analysis, plywood costs.

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