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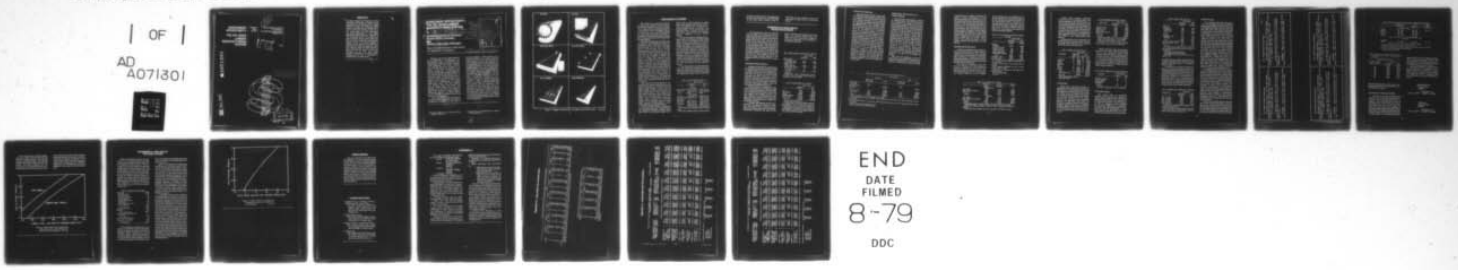

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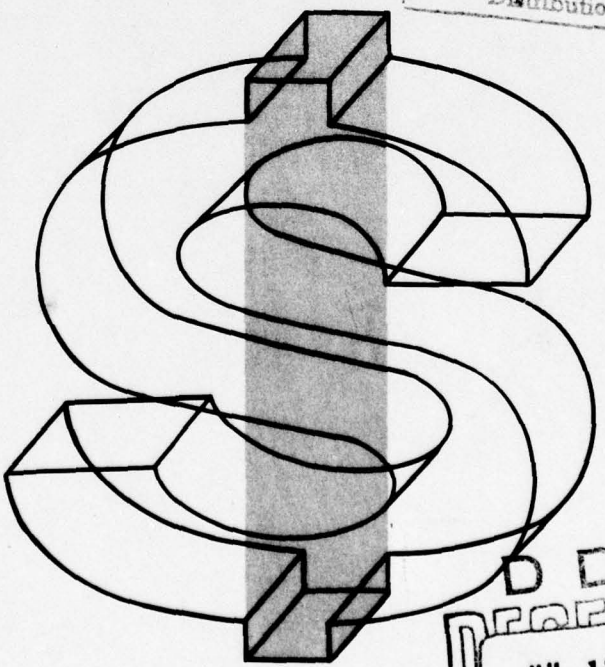
INVESTMENT OPPORTUNITY:

THE FPL EGAR LUMBER MANUFACTURING SYSTEM

Research Paper FPL 310

Forest Products Laboratory
Forest Service
U.S. Department of Agriculture
Madison, Wis.

1979



ABSTRACT

A model of present-day computer-controlled sawmilling technology is modified for the manufacture of any desired width of EGAR dimension lumber from small logs. EGAR lumber is manufactured via headrig production of 2-inch-thick flitches which are in turn dried, edged full width, edge-glued, and gang-novelty-ripped to wide widths (EGAR). The EGAR system is compared to the unmodified version of the same computer-controlled sawmill. Both systems appear to be good investment opportunities; however, the 12 to 13 percent increase in lumber recovery gained by the EGAR system does not justify the additional investment required unless the EGAR sawmill is used to increase the amount of wide width dimension (2- by 10-in. and wider). Economic advantage of the EGAR system increases as the cost of roundwood increases relative to lumber prices.

INVESTMENT OPPORTUNITY: THE FPL EGAR LUMBER MANUFACTURING SYSTEM,

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Because more of the available sawtimber is comprised of second-growth and small-diameter logs, new sawmilling technologies are needed to maintain manufacturing efficiencies. This study compares two small-log sawmilling systems: (1) A model of a modern computer-controlled sawmill, termed here a conventional sawmill; and (2) the same system modified for the manufacture of any desired width of dimension lumber via headrig production of 2-inch-thick flitches. These flitches are successively dried, edged full width, edge-glued, gang novelty-ripped to desired dimensional widths, and then surfaced. This modified system thus warrants the acronym EGAR (*E*dge *G*lue *A*nd *R*ip) sawmill (fig. 1). Both mills are designed to manufacture dimension lumber. However, dimensional widths in the EGAR sawmill are not limited by log diameters as they are in the conventional sawmill.

This study assesses and compares the innovative EGAR sawmilling and modern, conventional sawmilling on the basis of economic feasibility. EGAR appears to be equally functional as a modern small-log sawmilling system (*1,4*).[2] This study has required detailed year-1976 base estimates of processing equipment, land, buildings, and operating requirements and costs (*4*). These estimates were in turn used to develop estimates of the unit costs of producing dimension lumber with each process. The two processes are then compared at various levels of investment profitability. The unit costs of production computed are f.o.b. average prices for mill products which were required in 1976 to provide designated levels of profitability from discounted cash flow analyses. The unit production costs computed include selling costs, taxes, depreciation, all other manufacturing costs, and profits. The results of analysis indicate that the EGAR system should provide a more attractive rate of return to investment than the conventional sawmill when EGAR is used to manufacture dimensional lumber 10 inches and wider.

[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[2] Italicized numbers in parentheses refer to literature cited at end of report.

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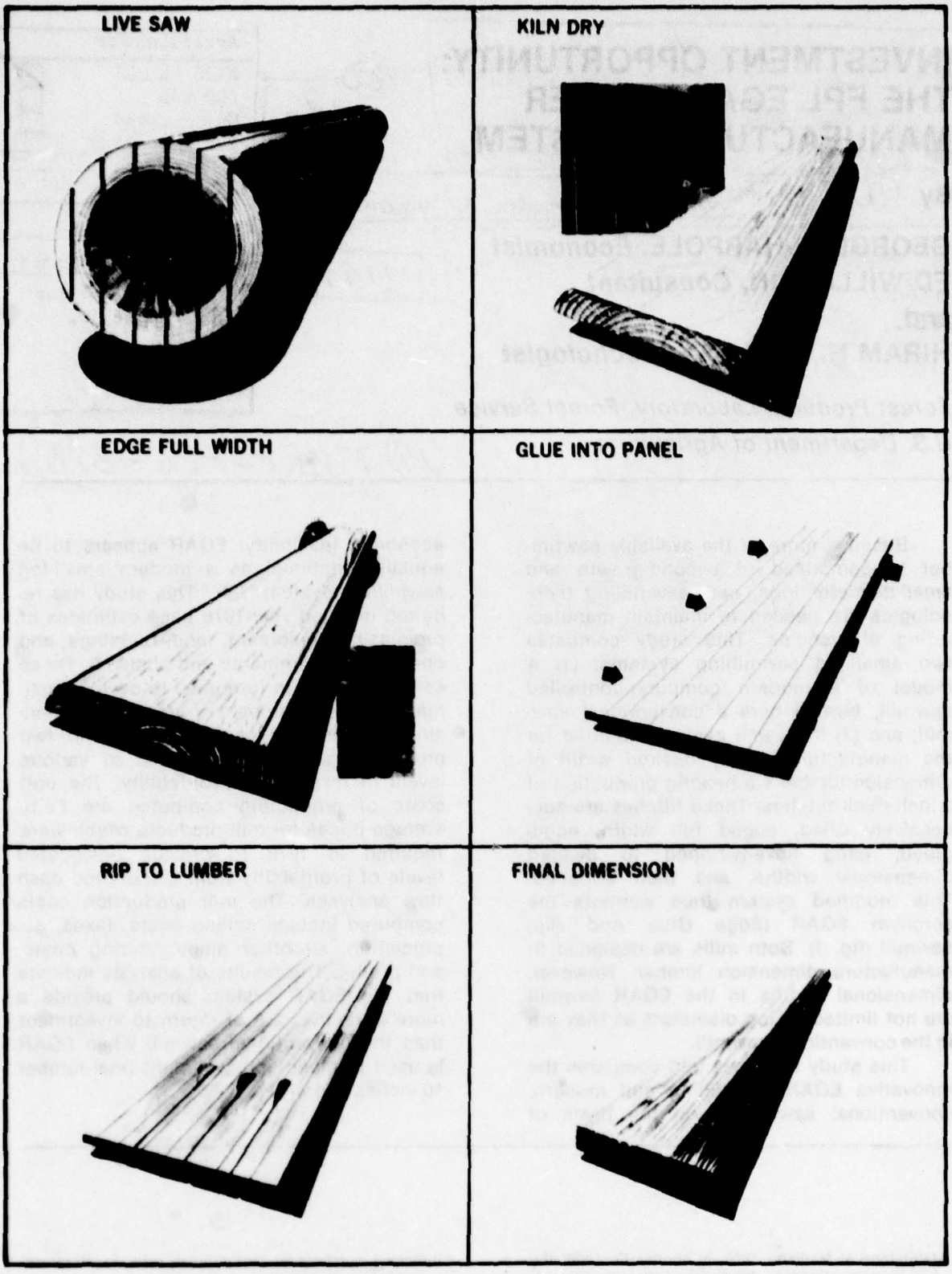

Figure 1.—Stages in the production of lumber by the EGAR Process. (M 145 756)

PROCESSING SYSTEMS

Both EGAR and conventional sawmill processes were designed to use commercially available equipment suited to processing of many domestic softwood dimension lumber species, such as Douglas-fir, southern yellow pine, and the true firs (appendix A). In this study, calculated heat energy requirements for drying were based on Douglas-fir and would require some modification for other species.

Both the conventional and EGAR sawmill systems were designed to process approximately 71,481 cunits (100 ft^3) per year, assuming logs 5 to 15 inches in diameter and 8 to 20 feet long, and a two-shift, 250-day-per-year operating basis. A computerized simulation of lumber manufacture from logs 5 to 12 inches in diameter was made for both processes to provide estimates of lumber and byproduct output (table 1 and appendix B). This simulation assumes that logs for both systems are sorted for length to gain the average feed rate of six logs per minute at the quad-band headrig. This log feed rate implies a rate for 8-foot-long logs of 8 per minute, and for 18- and 20-foot-long logs, 4 per minute. This rate represents a 50 percent increase in headrig productivity as compared to unsorted log processing. Dry kiln capacities and all items of processing equipment are scaled to accommodate these log flow requirements.

Both sawmills lend themselves to conventional live sawing, *B*est *O*pening *F*ace (BOF) live sawing (*4*), or EGAR live sawing (lightly edged flitches at equal log and board throughput rates). Basic patterns include sawing logs to two nominal 2-inch side boards and 2-inch center flitches until sawn to a 4-inch center flitch. The 4-inch center flitch is then resawn at the horizontal resaw to make two 2-inch-thick flitches. If log diameters result in 6-inch center flitches, a merry-go-round is available to again resaw oversized flitches.

The 2-inch-thick flitches are edged on slat bed feed systems (two) supplying laserline equipped sidehead chipping edgers (two). Each of the chipping edgers has a splitter saw to permit splitting for grade when conventional or BOF sawing to minimize drying degrade from cup and twist. A trimmer bypass system is provided. This limits the number of pieces handled by the trimmerman and minimizes the wasteful need for "slashing" to clear a flooded trimmer.

Dry kiln and planermill systems are consistent with conventional processes. Additional capacity is provided for the EGAR system to handle the additional volume of material recovered from the green end for lumber manufacture. The edge glue department for the EGAR sawmill follows drying in the processing sequence, whereas the planermill follows drying in the conventional sawmill. In both the conventional and EGAR processes lumber is unstacked to remove stickers, and restacked after kiln drying to make a solid package. This procedure is used in the conventional sawmill to facilitate the feed rate required by high planermill speeds.

In the EGAR sawmill's edge glue department, five straight line edge-rip and five glue machines are fed by a common feed table, where panels 52 to 56 inches wide are made by edge-gluing random width 2-inch-thick

Table 1.—Wood raw material input/output

	Type of sawmill	
	Conventional	EGAR
	Cunit	Cunit
MILL INPUTS		
Bark and log trim[1]	10,722.1 (15.0 pct)	10,722.1 (15.0 pct)
Trimmed logs	71,480.9 (100.0 pct)	71,480.9 (100.0 pct)
Total	82,203.0	82,203.0
MILL OUTPUTS[2]		
Dry lumber	35,015.6 (49.0 pct)	39,480.0 (55.2 pct)
Dry planer shavings	4,844.5 (6.8 pct)	5,412.6 (7.6 pct)
Dry sawdust	—	1,872.6 (2.6 pct)
Green sawdust	8,877.7 (12.4 pct)	7,546.1 (10.6 pct)
Wood chips	20,241.1 (28.3 pct)	14,230.4 (19.9 pct)
Shrinkage loss	2,502.0 (3.5 pct)	2,939.2 (4.1 pct)
Total	71,480.9 (100.0 pct)	71,480.9 (100.0 pct)

[1] Bark and log trim volume expressed as ratios to trimmed log volumes.

[2] Mill outputs: Percentages are based on trimmed log inputs.

flitches of the same lengths. The edge-glued panels are then placed into rough-dry storage for later gang novelty ripping to order for width. They are then surfaced on two sides, and edges are eased using a conventional planer.

COMPARATIVE ANALYSIS OF PRODUCTION COSTS

For both sawmills, total unit production costs are used as an investment criterion. Total unit production costs include manufacturing costs as well as taxes, depreciation, selling costs and profits, and may be regarded as the 1976 product selling prices (f.o.b. mill) which would have been required to yield indicated rates of return (ROR) from discounted cash flow analyses (appendix C). The ROR is the particular rate of interest that will yield a present value of zero when used to discount the annual stream of after-tax net cash flows. To the corporation, this is the after-tax interest earnings realized on the amortized financing requirements of investment.

Investment Requirements

Investment requirements are twofold: (1) To establish the physical facilities needed for lumber production, and (2) to supply working capital to cover costs for roundwood supplies, resin, fuel, goods in process, accounts receivable, and other inventories of unsold products. Investment costs are the costs incurred for the purpose of producing future revenues. The initial 1976-based investment costs are summarized in tables 2 and 3 for the conventional and EGAR sawmills.

Working capital is computed as a percent of the annual sum of variable and fixed costs, less selling expense, to accommodate the out-of-pocket costs carried in the form of raw materials and finished products until such costs can be reimbursed from cash sales of product outputs. This time period is assumed to be approximately 6 weeks (12.5 pct) for both sawmills.

In the cash flow analyses used to calculate total unit production costs, an investment tax credit equal to 10 percent of the cost of processing equipment is considered; depreciation allowances are used on the basis of Federal asset depreciation guidelines; 51.12 percent effective state and Federal tax rate is used, and a 10-year economic life is assumed for the operation of the described facilities.

Table 2.—Facility capacities and investment costs—1976 basis

	Type of sawmill	
	Conventional	EGAR
Annual capacities:		
Log throughput (cunits)	71,481	71,481
Lumber output (Mfbm)	61,821	69,704
Investment costs:		
Facilities[1] (M of dol)	8,880	12,097
Working capital[2] (M of dol)	783	898
Total investment costs (M of dol)	9,663	12,995

[1] See table 3.

[2] Working capital = 12.5 pct × manufacturing costs; manufacturing costs = costs of raw materials, energy, processing labor, administrative, and factory overhead.

Table 3.—Facilities investment costs—1976 basis

	Type of sawmill	
	Conventional	EGAR
	Dol	Dol
Land[1]	61,250	61,250
Site preparation	265,000	265,000
Buildings	2,026,905	2,780,155
Processing equipment[2]	6,104,481	8,533,750
Mobile equipment[3]	422,304	456,804
Total costs	8,879,940	12,096,959

[1] Land: 24.5 acres at $2,500 per acre.

[2] Processing equipment costs include engineering, installation, and contingency (10 pct of total costs) costs. Investment tax credit calculated as 10 pct of the processing equipment costs.

[3] Mobile equipment is assumed to have a 5-year economic life, a salvage value of 10 pct of original cost, and to be replaced at costs of $538,979 (conventional mill) and $583,010 (EGAR mill) at the end of the fifth year of operations.

Production Capacities

Both sawmills are sized for log throughput volumes of approximately 71,480 cunits of roundwood. By utilizing *Best Opening Face* sawing techniques, via log scanning and computer controlled sawing at the headrig, approximately 61,821 thousand board feet (35,015.6 cunits) of dry finished lumber will be produced annually from the conventional mill. By sawing logs in the EGAR sawmill to the widest possible 2-inch-thick flitches at the headrig, then edge gluing the kiln-dried flitches into wide panels for continuous ripping to wide dimensions, approximately 69,794 thousand board feet (39,480.0 cunits) of lumber will be produced annually. The balance of the log throughput volumes is recovered as processing residues with some volumetric loss due to shrinkage (table 1). For analysis, it is assumed that startup losses of production time will reduce throughput volumes of both sawmills to 80 percent of capacity in the first year, and to 95 percent of capacity in the second year. Production is assumed to be maintained at full operating capacity in the third and each succeeding year.

Heat-Energy Requirements for Lumber Drying

Both sawmills are designed to produce dry finished lumber. The conventional sawmill is assumed to operate on the basis of drying green lumber at 100 percent green moisture content (MC), dry basis, to a level of 15 percent MC (dry basis). The EGAR sawmill is assumed to dry all flitches from 100 percent MC to 10 percent MC—as required for edge gluing. The volume of wood dried includes the green volumes of lumber, planer shavings, and dry sawdust. Heat-energy requirements are based on the estimate that it takes 2,750 Btu's to remove each pound of water and on an ovendry weight, at green volume, of 28.1 pounds per cubic foot for Douglas-fir. The estimated annual heat-energy requirements for the conventional mill, at full operating capacity, are 278,262.6 x 10^6 Btu's for the conventional mill and 345,671.9 x 10^6 Btu's for the EGAR mill (table 4).

Both mills are designed to utilize as much volume of processing residues as practicable for the generation of the heat energy required for steam-supplied dryer heat. Sup-

Table 4.—Annual heat-energy requirements and fuel supplies for dry kilns

	Type of sawmill			
	Conventional		EGAR	
	Thousand cubic feet of wood[1]	10^6 Btu's	Thousand cubic feet of wood	10^6 Btu's
Kiln throughput:				
Green lumber[1]	4,236.4	—	4,970.3	—
Heat-energy required	—	[2]278,262.6	—	[3]345,671.9
Fuel supplies:				
Oil[4]	—	41,739.4	—	51,850.8
Bark of log trim[5]	1,072.2	174,296.8	1,072.2	174,296.8
Green sawdust[5]	382.8	62,226.4	735.3	119,524.3
Subtotal	1,455.0	278,262.6	1,807.5	345,671.9

[1] Includes green volumes of lumber, planer shavings, and dry sawdust.

[2] Assumes drying from 100 pct to 15 pct, dry basis; ovendry weight at green volume of 28.1 lb/ft³ for wood; and 2,750 Btu's per pound of H_2O removed.

[3] Assumes drying from 100 pct to 10 pct, dry basis; ovendry weight at green volume of 28.1 lb/ft³ for wood; and 2,750 Btu's per pound of H_2O removed.

[4] Assumes 15 pct of Btu requirement fueled with oil.

[5] Assumes effective heat value of 162,560 Btu's per ft³.

plemental fuels are needed to establish and maintain furnace temperatures at which green wood fuels can be efficiently burned. The supplemental fuel is assumed to be supplied by oil and to provide approximately 15 percent of the effective Btu requirements. The balance of fuel requirements are supplied from bark, log trim, and green sawdust residues (table 4). Douglas-fir bark and greenwood residues are assumed to yield 162,560 effective Btu's per cubic foot of solid wood content—65 percent of their higher heating value of 8,900 Btu's per pound, ovendry weight. The remaining volumes of wood residue materials are assumed to be sold (table 5).

Variable Operating Costs

Variable costs depend either directly or indirectly on the volume of lumber produced. These costs include selling costs, processing labor costs, and the costs for roundwood, resin, electricity, oil, shipping, and mobile equipment operation. All costs and revenues are assumed to increase 5 percent each year from the 1976 base estimates.

The costs for roundwood, resin, electricity, oil, shipping, and mobile equipment operation are assumed to vary directly with the annual output of lumber from each mill. After deducting the value of surplus processing residues (table 5), the unit variable costs—referred to as "raw material cost" in the discounted cash flow analyses (appendix B)—are $79.48 per thousand board feet for the conventional sawmill and $75.62 per thousand board feet for the EGAR sawmill (table 6). Second growth Douglas-fir log supplies of No. 2 and No. 3 Sawmill grade are assumed to cost $160 per thousand board feet, log scale (220 ft³/Mfbm).

Table 6.—Per unit variable costs of raw materials and supplies—1976 basis

	Type of sawmill	
	Conventional	EGAR
	Dol/Mfbm	Dol/Mfbm
Cost items:		
Roundwood[1]	84.091	74.581
Resin (30¢/lb, solids)[2]	—	2.056
Electricity (2¢/kWh)[3]	1.385	1.319
Oil (415/6 × 10⁶ Btu's)[4]	1.985	2.188
Shipping ($2.50/Mfbm)	2.500	2.500
Mobile equipment operation[5]	.50	.50
Subtotal	90.461	83.144
Less value of residues[6]	10.980	7.522
Net variable costs	79.481	75.622

[1] No. 2 and No. 3 sawmill, Douglas-fir logs: $160/Mfbm, log scale (220 ft³/Mfbm).

[2] Assumes 40 lb of glue/M ft² of glue line and 6.84 lb of glue/Mfbm.

[3] Annual requirement: Conventional mill = 764.7 × 10⁶ kWh; EGAR mill = 820.6 × 10⁶ kWh.

[4] Supplementary fuel requirement for kilns assumes 85 pct efficiency. See table 3.

[5] Gas, oil, and service supplies.

[6] See table 5.

Table 5.—Value of residue surplus—1976 basis

	Cubic volume	Unit value	Total value
	1,000 ft³	Dol/1,000 ft³	Dol
	CONVENTIONAL MILL		
Green sawdust	505.0	[1]62.50	31,563
Planer shavings and sawdust	484.5	[2]175.44	85,000
Wood chips	2,024.1	[3]277.78	562,255
Combined	3,013.6	205.19	678,818
	EGAR MILL		
Green sawdust	19.3	[1]62.50	1,206
Planer shavings and dry sawdust	728.5	[2]175.44	127,808
Wood chips	1,423.0	[3]277.78	395,281
Combined	2,170.8	241.52	524,295

[1] Assuming green sawdust = $5/200 ft³ unit (80 ft³, solid wood) = $62.50/M ft³, solid wood.

[2] Assuming planer shavings and sawdust = $10/200 ft³ unit (57 ft³, solid wood) = $175.44/M ft³, solid wood.

[3] Assuming wood chips = $20/200 ft³ unit (75 ft³, solid wood) = $277.78/M ft³, solid wood.

Under normal operating conditions, some portion of the processing labor costs may be expected to vary with production volume but are estimated to support a full level of manning during each year of operation on a two-shift, 250-day-per-year basis. There are 77 persons required to man processing work stations in the conventional mill and 92 persons in the EGAR sawmill. An average hourly rate of $6.00 per hour is assumed with 30 percent added to cover fringe benefit costs (table 7).

Selling costs for the conventional and EGAR sawmills are assumed to be 7 percent of annual gross revenues. These costs are assumed to cover trade discounts.

Table 7.—Processing labor costs—1976 basis

Work stations[1]	Type of sawmill			
	Conventional		EGAR	
	Persons	Costs[2]	Persons	Costs[2]
	No.	Dol	No.	Dol
Log handling	12	144,000	12	144,000
Sawmill	32	384,000	32	384,000
Dry kilns	6	72,000	6	72,000
Steam plant	3	36,000	3	36,000
EGAR	—	—	17	204,000
Planermill	20	240,000	18	216,000
Shipping	4	48,000	4	48,000
Subtotal	77	924,000	92	1,104,000
Fringe benefits (30 pct)		277,200		331,200
Total costs		1,201,200		1,435,200

[1] Assumes two-shift operation, 250 d/yr.
[2] Hourly rate = $6.00/h.

Fixed Costs

Fixed costs are those incurred independently of the volume of production and are referred to as administrative and factory overhead costs. Administrative costs include the payroll costs—including fringe benefits—for administrative, supervisory, clerical, and janitorial personnel and for miscellaneous utility services and contingencies (table 8). The 1976 base costs, which are estimates of apparent need for each facility, increase 5 percent each year. An additional $10,000 is added to administrative costs for the EGAR sawmill for each of the first 3 years to cover promotional and other marketing expenses.

Table 8.—Administrative overhead costs—1976 basis

Type of costs	Type of sawmill	
	Conventional	EGAR
	Dol	Dol
Administrative salaries[1]	53,300	53,300
Supervisory salaries[1]	124,800	166,400
Clerical salaries[1]	11,700	11,700
Janitorial and contingencies[2]	93,600	140,400
Utility services[3]	10,000	10,000
Total costs	293,400	[4]381,800

[1] Including fringe benefits equal to 30 pct of base salaries.
[2] Includes costs for travel, telephone, and office supplies.
[3] Includes costs for water and electrical service to office.
[4] Ten thousand dollars is added for each of the first 3 years to cover promotional costs for marketing of EGAR lumber.

Factory overhead costs include maintenance, repairs, taxes, insurance, operating supplies, and contingency costs. These costs are assumed to vary with the factory investment costs of the described facilities, i.e., facilities investment costs less the cost for land (table 2). Factory overhead costs are assumed to be 9.5 percent of factory investment costs for both the conventional and EGAR sawmills (table 9).

Table 9.—Factory overhead costs as percent of factory costs[1]

Type of costs	Type of sawmill	
	Conventional	EGAR
	Pct	Pct
Maintenance and repairs	6.5	6.5
Taxes and insurance	2.0	2.0
Operating supplies	.5	.5
Contingencies	.5	.5
Total costs	9.5	9.5

[1] Factory costs = facilities costs − cost of land ($61,250).

Production Costs

The annual flows of investment, operating costs, and revenues required to yield a 15 percent ROR for the conventional and EGAR sawmills are given in appendix C. The unit prices computed are those required to cover all production costs—including the 15 percent ROR level of profitability prescribed. The average distribution of revenues to costs are summarized in terms of the 1976 unit price required to cover profitability and costs (table 10). Unit sales prices,

Table 10.—Production costs—1976 basis

	Type of sawmill	
	Conventional	EGAR
	Dol/Mfbm	Dol/Mfbm
Variable costs:		
Raw materials[1]	79.48	75.62
Processing labor	19.83	21.01
Selling expense[2]	11.87	12.46
Total	111.18	109.09
Fixed costs:		
Manufacturing costs[3]	18.67	22.36
Depreciation	9.16	10.95
Total	139.01	142.40
Taxes (51 pct for state and Federal)	14.80	17.23
After-tax profit (ROR = 15 pct)[4]	15.72	18.42
Total costs	169.53	178.05

[1] Raw material costs include wood, resin, power, shipping, and mobile equipment operating costs, less revenues from wood residues. See table 6.

[2] Selling expense is 7 pct of gross revenues.

[3] Includes administrative and factory overhead.

[4] Profit required to yield an after-tax internal rate of return (ROR) of 15 pct.

or production costs, cover the requirements for taxes, selling expenses, and profit at the after-tax prescribed levels of profitability (tables 10 and 11).

To maintain one of the given profitability levels (0 to 30 pct), analysis indicates that lumber produced from the EGAR sawmill will cost about $6 to $22 per thousand board feet more than lumber produced from the conventional sawmill (table 11). If the differential in production costs for the conventional and EGAR sawmills, at given levels of profitability, is less than the expected differentials in market values, the EGAR sawmill will be a comparatively more profitable investment.

Table 11.—Production costs at different levels of profitability[1]

Profitability level[2]	Type of mill	
	Conventional	EGAR
	Dol/Mfbm	Dol/Mfbm
ROR = 10 percent	156.93	163.24
ROR = 15 percent	169.53	178.05
ROR = 20 percent	183.12	194.06
ROR = 25 percent	197.60	211.17
ROR = 30 percent	207.18	229.24

[1] Production costs include costs for taxes, depreciation, selling expenses, and profits. See table 10.

[2] Rate of return (ROR) is the interest rate that yields a present value of zero when used as a discount factor to determine the present or future value of annual net cash flow.

Product Prices

F.o.b. Portland prices for dry Douglas-fir 2 by 4 R/L Standard and Better dimension averaged about $185 per thousand board feet and ranged from $152 to $217 per thousand board feet during 1976. Using lumber grade recovery data for second-growth Douglas-fir, as measured in a sawmill study by the U.S. Forest Service (*3*), and the f.o.b. Portland, Oreg., product prices from 1976 issues of "Random Lengths" price reporter (*2*), the average value of lumber output from a small log mill would be about $190 per thousand board feet and range between $156 and $223 per thousand board feet—about 3 percent more than the price of 2 by 4 R/L Standard and Better. Assuming the lumber recovery data used and price differentials derived from "Random Lengths" price reports, 2 by 4 R/L Standard and Better would need to be about $165 per thousand board feet for the product mix of the conventional sawmill to yield an average value of $169.53 per thousand board feet from the conventional sawmill—where production cost of $169.53 per thousand board feet includes sufficient profit to yield a 15 percent ROR (table 12).

To compare the average value of lumber from the EGAR sawmill to the conventional sawmill we need to estimate a likely product mix and apply this estimate to corresponding product prices from the conventional mill's product mix (table 12). There is a possibility for upgrading lumber in the EGAR system by directing the largest defects to 10-inch and wider lumber. For analysis, however, this possibility is ignored. As for the conventional mill, 93.78 percent of the EGAR mill output is assumed to be Standard and Better, 4.96 percent to be Utility, and 1.26 to be Economy. With freedom to manufacture whatever widths of dimension may provide the highest returns, it is assumed that the EGAR sawmill will produce only 10-inch and wider dimension.

Assuming the EGAR sawmill produces only 10-inch and wider dimension, the average value of lumber output will be about 22 percent greater than for the conventional mill and 25 percent greater than the market price for 2 by 4 R/L Standard and Better (table 13). At any given market level, analysis indicates

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KEYWORDS: Computer-controlled sawmill, EGAR system, lumber recovery, small logs, wide dimension lumber.

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Table 12.—Product mix, unit prices, and average value for conventional and EGAR sawmills[1]

	Standard and Better	Utility	Economy
	Dol/Mfbm (%)	Dol/Mfbm (%)	Dol/Mfbm (%)
	Conventional Mill[2]		
2 by 4-R/L	165 (22.6)	119 (1.2)	83 [3](1.2)
2 by 6-R/L	166 (18.4)	107 (1.0)	
2 by 8-R/L	168 (37.4)	88 (1.9)	
2 by 10-R/L	214 (12.6)	88 (0.7)	
2 by 12-R/L	214 (2.8)	88 (0.2)	
	Average value of product mix = $169.53/Mfbm (ROR = 15 pct)		
	EGAR Mill		
2- by 10- and wider-R/L	214 (93.8)	88 (5.0)	83 (1.2)
	Average value of product mix = $206.13/Mfbm (ROR = 24 pct)		

[1] Price differentials derived from 1976 "Random Lengths" price reporter.

[2] Product grade recovery for No. 3 sawmill logs derived from U.S. Forest Serv. Res. Pap. PNW 177, 1974. Lumber size recovery derived from FPL simulation analyses.

[3] Economy: Random length and width.

Table 13.—Average unit prices of lumber output from a conventional and EGAR sawmill compared at different market levels —1976 basis

Corresponding market values		
2 by 4-R/L, Douglas-fir Standard and Better	Type of mill	
	Conventional	EGAR
	Dol/Mfbm	Dol/Mfbm
150	154.12	187.39
160	164.39	199.88
170	174.67	212.38
180	184.94	224.87
190	195.22	237.36
200	205.49	249.86
210	215.77	262.35
220	226.04	274.84

that the EGAR sawmill will be about 9 percentage points more profitable than the conventional sawmill (fig. 2).

Sensitivity of Production Costs

In the discounted cash flow analyses, all costs and unit prices were increased 5 percent per year to approximate annual increases in real costs and prices from the 1976 base year. To the extent this assumption reflects the trend of real costs and prices, the production costs expressed in this paper may be suitably adjusted to subsequent years by multiplying the 1976 base production costs by annual adjustment factors = $(1.05)^n$, where n = the number of years production costs are to be adjusted forward. That is, to adjust production costs to a 1977 basis a factor of 1.05 should be used; to adjust production costs to a 1978 basis, a factor of 1.1025 should be used; and so forth.

As product prices rise, roundwood costs may be expected to rise. Production costs may be assessed for sensitivity to roundwood costs, or adjusted to accommodate new assumptions about roundwood costs and profitability, by using the following formulas:

$$\begin{matrix}\text{Conventional mill's}\\ \text{production cost}\\ (\$/\text{Mfbm})\end{matrix} = 35 + 2.7\,\text{ROR} + \begin{matrix}\text{Roundwood cost}\\ (\$/220\ \text{ft}^3)\end{matrix} \times 0.5900$$

$$\begin{matrix}\text{EGAR mill's}\\ \text{production cost}\\ (\$/\text{Mfbm})\end{matrix} = 56 + 3.2\,\text{ROR} + \begin{matrix}\text{Roundwood cost}\\ (\$/220\ \text{ft}^3)\end{matrix} \times 0.4625$$

Both formulas were derived algebraically from a series of discounted cash flow analyses using roundwood costs ranging from $140 to $200 per Mfbm, log scale (220 ft³/Mfbm), and ROR's ranging from 10 to 25 percent. The results obtained from discounted cash flow analyses were not linear, but the above formulas were found to calculate results within $1.50 of those computed by discounted cash flow analysis. Results indicate that an increase or decrease in wood costs of $1 per Mfbm, log scale, will cause a corresponding change of about 46¢/Mfbm, lumber tally, for the EGAR mill and about 59¢/Mfbm, lumber tally, for the conventional mill.

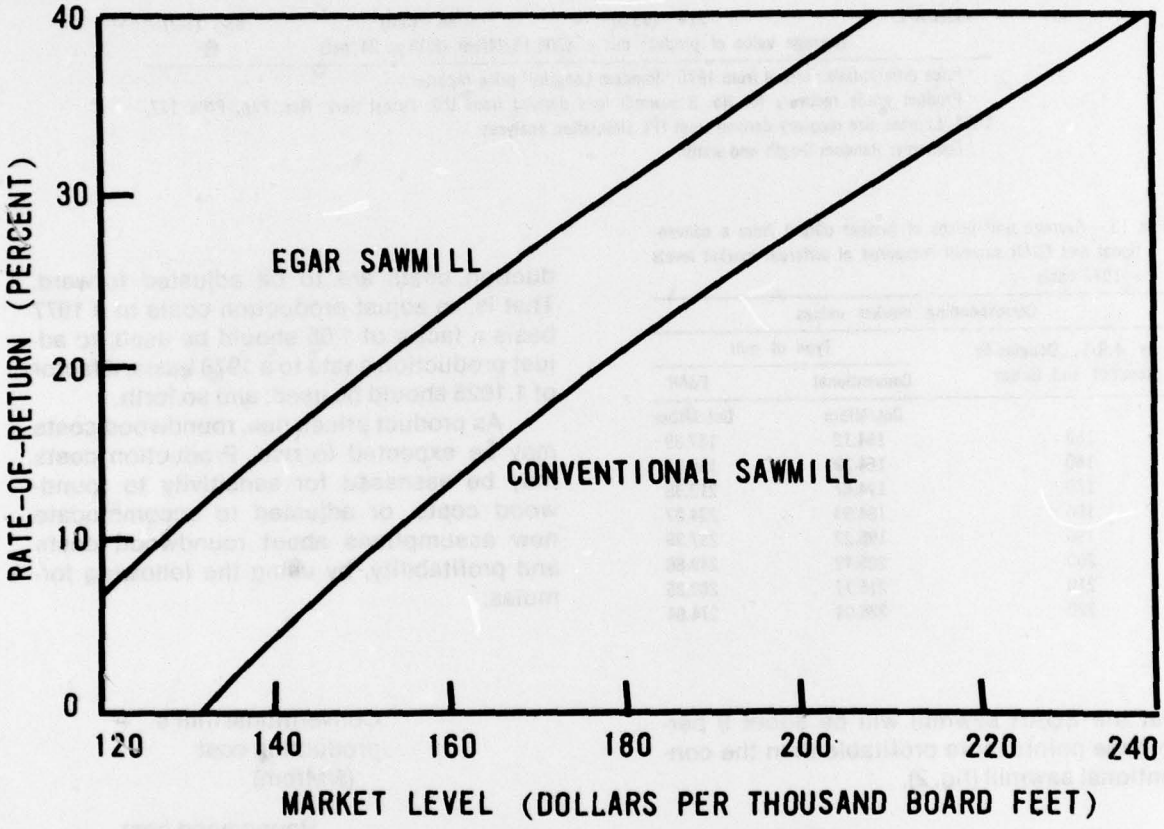

Figure 2.—Rate-of-return and market level (1976 basis) for 2 by 4 R/L Standard and Better, kiln-dried Douglas-fir. (M 146 199)

INCREMENTAL ANALYSIS OF THE EGAR SYSTEM

Because the EGAR sawmill is an alternative to a conventional sawmill, the additional investment required for the EGAR sawmill deserves special attention. The estimated cost for constructing the conventional sawmill was 8.9 million dollars, and for the EGAR sawmill 12.1 million dollars. The additional cost for construction of an EGAR sawmill is then about 3.2 million dollars. Additionally, the EGAR processing system requires 15 more people than the conventional sawmill. Thus, labor costs are about $3.43/Mfbm greater for the EGAR system (table 14). Also, differences in lumber and residue yields change most of the other production costs as well.

Table 14.—Incremental costs of EGAR system

Variable costs:	Dol/Mbf
Resin (30¢/lb, solids)	$ 2.06
Electricity (2¢/kWh)	.09
Oil ($15/(6 × 10⁶ Btu's))	.43
Shipping ($2.50/Mbf)	.28
Mobile equipment operation	.06
Processing labor	3.43
Selling expense (5 and 2 pct)	.60
Value of residues lost	2.20
Total variable cost	$ 9.15
Fixed manufacturing costs	$ 5.98
Depreciation	2.83
Total manufacturing cost	$17.95
Subtract value of increased lumber yield (at $170/Mbf)	17.90
Net manufacturing cost	.05
Taxes (5½ pct state and Federal)	4.04
After-tax profit (15 pct ROR)	4.42
Total processing cost	$ 8.51

Kiln throughput is increased by 10 to 13 percent in the EGAR sawmill to accommodate the increase in dry lumber yield plus the additional volume of edges found in drying full-width flitches. The gluing process requires that EGAR flitches be dried to about 10 percent MC (dry basis) instead of the 15 percent MC customary for conventional systems. The additional drying takes about one million more Btu's per thousand board feet of dry lumber output.

More fuel is needed for the heat-energy requirements of the EGAR system. We assumed the additional fuel would be 15 percent fuel oil and 85 percent wood residue. This increase in use of residues for energy coupled with the reduction in wood chips due to greater lumber yield results in a cost in residues lost of about $2.20/Mfbm. The increase in revenues gained from the sale of the additional 10 to 13 percent dry lumber, however, represents an increase of about $18/Mfbm when lumber output has an average value of about $170/Mfbm. This increase in revenues offsets other associated increases in costs of the EGAR system and is sufficient to yield some profit (about 3 pct ROR) upon analysis.

To generate enough profit to make the EGAR department an attractive investment, an after-tax ROR of 15 percent would probably have to be realized. To attain this level of profitability, EGAR lumber would have to be sold for about $8/Mfbm more than lumber from the conventional mill to cover all costs plus the taxes and profit required to yield the 15 percent ROR. The value added to the lumber product mix is then the source of profitability for the additional, or incremental, investment required by the EGAR processing system (fig. 3). As previously indicated, the average value of EGAR lumber could probably be increased by about 22 percent over a conventional small log mill's lumber if only 2-by 10-inch and wider lumber were produced. If the average value of the conventional mill's lumber were worth $170/Mfbm (sufficient to yield a 15 pct ROR for the conventional mill) then the EGAR lumber would be worth about $207/Mfbm. The value added by the EGAR mill would be about $37/Mfbm and yield an after-tax ROR of about 45 percent for the EGAR department.

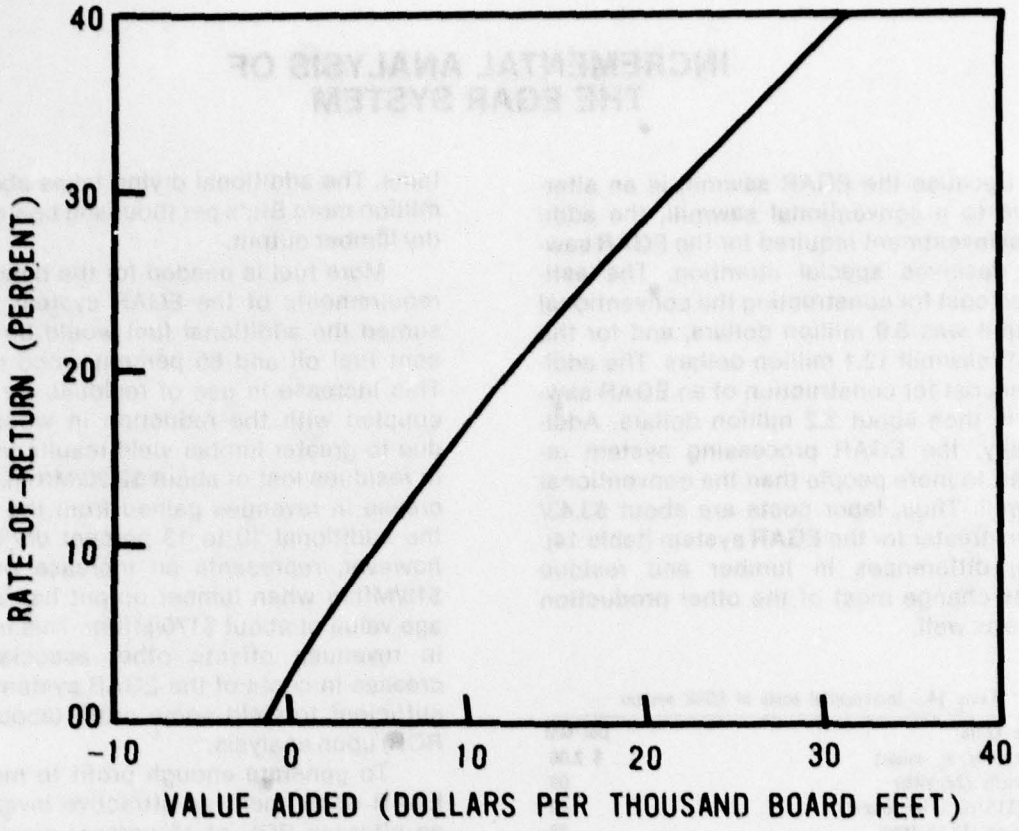

Figure 3.—Value added and profitability of incremental investment in EGAR sawmill (1976 basis). (M 146 198)

CONCLUSIONS

Both the conventional and EGAR sawmills appear to be good investment opportunities for the conversion of small diameter timber. Given the same average realization for lumber output, the 12 to 13 percent increase in lumber recovery gained by the EGAR sawmill does not appear to justify the additional investment required for the EGAR sawmill. However, assuming that the EGAR sawmill will be used to increase the amount of wide-width dimension produced, the economic analyses indicate that the EGAR system will readily justify the additional investment requirement.

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APPENDIX A

The scope, parameters, and assumptions for an EGAR sawmill are as follows:

Volume	:	25-50 million bf/year on a 2-shift basis.
Species	:	Southern yellow pine Douglas fir White fir
Log size	:	5-11 inch diameter—average 8 inches.
Log length	:	8-20 feet.

Primary breakdown.—Capability is required to split down the middle or offset to one-half of 8/4 target size. Ability to skew the log to taper saw is not required.

Sawmill edging.—It will be necessary to edge rough green for handling and drying. It is assumed that rough green will be edged 1 inch over width of rough green target. This recognizes that in an EGAR sawmill the edgerman would rip back only sufficiently to improve handle ability and avoid drying large volumes of edgings.

Trimming.—Assume trim of round backs and feather ends to nearest even foot.

Green sort.—J-bar sort by length. Lengths (in feet) will be 8-10-12-14-16-18-20 plus 2 or 3 extra pockets.

Kiln drying.—Drying will be by most modern proven technology, i.e., elevated temperature or regular temperature schedules depending on species. Anticipated added kiln capacity because of lightly edged flitches will be 10 percent.

Unstack for straight line rip.—Provide a dropout behind the dry end unstacker to remove all badly cupped pieces. This probably means all cupped pieces over 8 inches wide. These will be ripped back.

Blanking.—It is assumed blanking will not be required if size variation can be held to ± .0625.

EGAR laminating.—Two alternatives are:

1. Radio frequency with 51 inches x 100 inches or longer machines in the number required.
2. Residual heat plus preheat of edge. Press load width will be held as close to maximum as possible by inserting ripped edge strips or other sizes from readily available assortments.

Panel rip.—Panel ripping to final lumber width is based on the assumption that final size can be achieved by ripping without further dressing that would remove an appreciable amount of stock (i.e., not more than light touch sand, or equivalent). Further assumption is that corners will need to be broken. It is not certain whether set accuracy for a large number of saws is sufficient to allow ripping all pieces simultaneously with a single settable gang rip. This is no big problem since adequate time is available to rip in single lines if necessary. Some form of settable gang is desired, however, from economy-of-space standpoint.

Surfacer.—Final surfacing on wide faces will be with conventional top and bottom blanker (or abrasive planer where sawing variation is minimal). If stacked ahead of this single width, this would be the logical place to break corners.

Appendix B.—Log profile and recovery data.

Table B-1.—Distribution of log diameters and lengths used for manufacturing simulation analysis[1]

Diameter	Length															
	8 feet		10 feet		12 feet		14 feet		16 feet		18 feet		20 feet		Total	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
5	1	0.300	—	—	6	1.802	9	2.703	14	4.204	2	0.601	1	0.300	33	9.910
6	3	.901	5	1.502	12	3.604	13	3.904	14	4.204	4	1.201	5	1.502	56	16.817
7	1	.300	4	1.201	15	4.505	9	2.703	18	5.405	5	1.502	3	.901	55	16.517
8	—	—	15	4.505	10	3.003	11	3.303	13	3.904	5	1.502	4	1.201	58	17.417
9	2	.601	10	3.003	8	2.402	12	3.604	17	5.105	8	2.402	1	.300	58	17.417
10	1	.300	7	2.102	8	2.402	8	2.402	15	4.505	5	1.502	1	.300	45	13.514
11	1	.300	2	.601	5	1.502	4	1.201	3	.901	3	.901	—	—	18	5.405
12	—	—	1	.300	1	.300	4	1.201	4	1.201	—	—	—	—	10	3.303
Total	9	2.703	44	13.213	65	19.520	70	21.021	98	29.429	32	9.610	15	4.505	333	100.00

[1] The log mix in this table was obtained by combining the actual log samples found in four Sawmill Improvement Project (SIP) studies. These studies were conducted under the supervision of USFS State and Private personnel. They were chosen because their diameter range coincided almost exactly with the study's requirements.

Table B-2.—Lumber recovery for conventional sawmill from manufacturing simulation analysis[1]

Length/size	2 by 4	2 by 6	2 by 8	2 by 10	2 by 12	Total
Ft	Mfbm					
8	1,006	312	208	173	—	1,699
10	2,675	1,463	2,948	705	130	7,921
12	3,642	1,756	3,641	1,301	156	10,496
14	2,852	2,504	4,977	1,821	728	12,882
16	3,121	4,578	7,838	2,514	832	18,883
18	819	819	3,902	1,561	—	7,101
20	780	715	1,127	217	—	2,839
Total	14,895	12,147	24,641	8,292	1,846	61,821

[1] This lumber mix is a summation of the individual log output when all logs in table 15 are processed by the Best Opening Face (BOF) sawing system modeling program and then expanded to the annual production level.

Appendix C.—Discounted cash flow analyses.

EGAR MILL--71,480.0 CUNIT THROUGHPUT/69,700 MBF OUTPUT --INTERNAL ROR/MBF
(INVESTMENT TAX CREDIT OF $ 853375. CONSIDERED.)

INITIAL INVESTMENT--YEAR 0	EFFECTIVE TAX RATE .5112	ORIGINAL CASH EQUITY	$ 0.	VAR. COSTS/SALES =	.6127
FACILITIES COST $12096959.	BORROWING RATE .0000	ENDING VALUE OF EQUITY	$15819622.	FIXED COSTS/SALES=	.1871
WORKING CAPITAL $ 898615.	REINVESTMENT RATE .0000	FACILITIES SALVAGE VALUE	$ 3272340.	TAX COSTS/SALES =	.0967
TOTAL INVEST. $12995373.	INTERNAL ROR .1500	P.V. OF INVST.(I=.1500)	$ 1.	A.T. PROFIT/SALES=	.1034

FINANCIAL SUMMARY WITH BREAK-EVEN ADJUSTED UNIT PRICES

YEAR-END VALUES . . .		YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
UNIT SALES		55763.	66219.	69704.	69704.	69704.	69704.	69704.	69704.	69704.	69704.
UNIT PRICE	$	178.05 $	186.95 $	196.30 $	206.12 $	216.42 $	227.24 $	238.60 $	250.53 $	263.06 $	276.21
GROSS SALES	$	9928662.$	12379800.$	13682936.$	14367084.$	15085438.$	15839710.$	16631694.$	17463279.$	18336462.$	19253284.
INTEREST INC-EXP		0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
GROSS REVENUES	$	9928662.$	12379800.$	13682936.$	14367084.$	15085438.$	15839710.$	16631694.$	17463279.$	18336462.$	19253284.
RAW MATERIAL COST	$	4216925.$	5257978.$	5811469.$	6102021.$	6407123.$	6727479.$	7063853.$	7417005.$	7787897.$	8177292.
PROCESSING LABOR		1435200.	1506960.	1582308.	1661423.	1744495.	1831719.	1923305.	2019470.	2120444.	2226466.
SELLING EXPENSE		695006.	866586.	957806.	1005696.	1055981.	1108780.	1164219.	1222430.	1283551.	1347728.
TOTAL VAR COST	$	6347131.$	7631524.$	8351563.$	8769141.$	9207598.$	9667977.$	10151376.$	10658905.$	11191892.$	11751487.
UNIT VAR COST	$	113.82 $	115.25 $	119.81 $	125.81 $	132.10 $	138.70 $	145.64 $	152.92 $	160.56 $	168.59
PROFIT CONTRI	$	3581531.$	4748276.$	5331374.$	5597943.$	5877840.$	6171732.$	6480318.$	6804334.$	7144550.$	7501770.
ADMIN. OVERHEAD	$	391800.$	410890.$	430934.$	451981.$	474080.$	497284.$	511640.$	537231.$	564092.$	592297.
FACTORY OVERHEAD		1143392.	1200562.	1260590.	1323620.	1389800.	1459291.	1532295.	1608960.	1689311.	1773777.
TOTAL F.C.	$	1535192.$	1611452.$	1691525.$	1765601.$	1853881.$	1946575.$	2043934.$	2146099.$	2253404.$	2366074.
FACILITIES COST	$	0.$	0.$	0.$	0.$	583010.$	0.$	0.$	0.$	0.$	-3272340.
WORKING CAPITAL		148634.	88611.	55470.	50557.	62534.	65661.	68944.	72391.	76011.	-1596229.
INVESTMENT	$	148634.$	88611.$	55470.$	50557.$	645544.$	65661.$	68944.$	72391.$	76011.$	-4868569.
DEPRECIATION	$	1693331.$	1306116.$	1140344.$	943726.$	786432.$	691536.$	691536.$	691536.$	691536.$	691536.
AFTER TAX PROFIT	$	1025925.$	855746.$	1221758.$	1411950.$	1582504.$	1727238.$	1838697.$	1938923.$	2052770.$	2172309.
A.T. EARNINGS		2719256.	2281862.	2362102.	2355682.	2368935.	2418770.	2522033.	2630459.	2744306.	2863845.
A.T. NET CASH FLOW		2570622.	2153251.	2306432.	2296125.	1723391.	2353109.	2453089.	2550867.	2668295.	7732415.
ACUM NET CASH FLOW	$	-10424.8M $	-8271.5M $	-5964.9M $	-3668.7M $	-1945.4M $	407.8M $	2860.8M $	5410.9M $	8087.2M $	15819.6M

INTERNAL RATES OF RETURN * * * AT ADJUSTED INPUT VALUES

	80 PCT	90 PCT	100 PCT	110 PCT	120 PCT
UNIT SALES	.086	.119	.150	.179	.207
UNIT PRICE	.021	.090	.150	.205	.257
UNIT VAR COST	.226	.188	.150	.110	.067
TOTAL F.C.	.166	.158	.150	.142	.134
FACILITIES COST	.183	.165	.150	.137	.126

U.S. GOVERNMENT PRINTING OFFICE: 1978 750126/48

CONVENTIONAL MILL--71,480.9 CUNIT THROUGHPUT/61,821 MBF OUTPUT --INTERNAL ROR/MBF
(INVESTMENT TAX CREDIT OF $ 610440. CONSIDERED.)

INITIAL INVESTMENT--YEAR 0		EFFECTIVE TAX RATE	.5112	ORIGINAL CASH EQUITY	$ 0.	VAR. COSTS/SALES =	.6558
FACILITIES COST	$ 8879040.	BORROWING RATE	.0000	ENDING VALUE OF EQUITY	611977359.	FIXED COSTS/SALES=	.1642
WORKING CAPITAL	$ 783960.	REINVESTMENT RATE	.0000	FACILITIES SALVAGE VALUE	$ 2438803.	TAX COSTS/SALES =	.0873
TOTAL INVEST.	$ 9663000.	INTERNAL ROR	.1500	P.V. OF INVST.(I=.1500)	$ 1.	A.T. PROFIT/SALES=	.0927

FINANCIAL SUMMARY WITH BREAK-EVEN ADJUSTED UNIT PRICES

YEAR-END VALUES . . .		YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
UNIT SALES		49457.	58730.	61821.	61821.	61821.	61821.	61821.	61821.	61821.	61821.
UNIT PRICE	$	169.53 $	178.01 $	186.91 $	196.25 $	206.06 $	216.37 $	227.18 $	238.54 $	250.47 $	262.99
GROSS SALES	$	8384348.$	10454234.$	11554680.$	12132414.$	12739035.$	13375986.$	14044785.$	14747024.$	15484376.$	16258594.
INTEREST INC-EXP		0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
GROSS REVENUES	$	8384348.$	10454234.$	11554680.$	12132414.$	12739035.$	13375986.$	14044785.$	14747024.$	15484376.$	16258594.
RAW MATERIAL COST	$	3930876.$	4901311.$	5417238.$	5688100.$	5972505.$	6271130.$	6584687.$	6913921.$	7259617.$	7622598.
PROCESSING LABOR		1201200.	1261260.	1324323.	1390539.	1460066.	1533069.	1609723.	1690209.	1774719.	1863455.
SELLING EXPENSE		586904.	731796.	808828.	849269.	891732.	936319.	983135.	1032292.	1083906.	1138102.
TOTAL VAR COST	$	5718980.$	6894367.$	7550389.$	7927908.$	8324303.$	8740510.$	9177548.$	9636422.$	10118243.$	10624155.
UNIT VAR COST	$	115.64 $	117.39 $	122.13 $	128.24 $	134.65 $	141.38 $	148.45 $	155.88 $	163.67 $	171.85
PROFIT CONTRI	$	2665368.$	3559867.$	4004292.$	4204506.$	4414731.$	4635468.$	4867241.$	5110603.$	5366133.$	5634439.
ADMIN. OVERHEAD	$	293400.$	308070.$	323473.$	339647.$	356630.$	374461.$	393184.$	412843.$	433485.$	455160.
FACTORY OVERHEAD		837770.	879664.	923648.	969830.	1018321.	1069237.	1122699.	1178834.	1237776.	1299665.
TOTAL F.C.	$	1131170.$	1187734.$	1247121.$	1309477.$	1374951.$	1443698.$	1515883.$	1591677.$	1671261.$	1754824.
FACILITIES COST	$	0.$	0.$	0.$	0.$	538979.$	0.$	0.$	0.$	0.$	-2438803.
WORKING CAPITAL		135882.	79797.	49929.	52426.	55047.	57799.	60689.	63724.	66910.	-1405110.
INVESTMENT	$	135882.$	79797.$	49929.$	52426.$	594026.$	57799.$	60689.$	63724.$	66910.$	-3843913.
DEPRECIATION	$	1216914.$	1000392.$	827175.$	688602.$	577743.$	533858.$	533858.$	533858.$	533858.$	533858.
AFTER TAX PROFIT	$	705534.$	670507.$	903382.$	1078501.$	1203488.$	1299187.$	1377194.$	1459101.$	1545108.$	1635606.
A.T. EARNINGS		1982448.	1670899.	1770557.	1767103.	1781187.	1833045.	1911052.	1992959.	2078962.	2169264.
A.T. NET CASH FLOW		1840562.	1591102.	1720628.	1714678.	1187161.	1775246.	1850363.	1929235.	2012052.	6013177.
ACUM NET CASH FLOW	$	-7816.3M $	-6225.2M $	-4504.6M $	-2789.9M $	-1602.7M $	172.5M $	2022.9M $	3952.1M $	5964.2M $	11977.4M

INTERNAL RATES OF RETURN . . . AT ADJUSTED INPUT VALUES

	80 PCT	90 PCT	100 PCT	110 PCT	120 PCT
UNIT SALES	.084	.119	.150	.179	.208
UNIT PRICE	.004	.082	.150	.211	.269
UNIT VAR COST	.201	.196	.150	.102	.050
TOTAL F.C.	.166	.158	.150	.142	.134
FACILITIES COST	.183	.165	.150	.137	.126