ECONOMIC ANALYSIS OF WOOD- OR BARK-FIRED SYSTEMS

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PREFACE

The Tennessee Valley Authority, in cooperation with the U.S. Department of Agriculture and the Forest Products Research Society, is preparing three slide-tape presentations to help people evaluate wood- and bark-fueled boiler systems as alternatives to ones using oil, gas, or coal. The first two presentations cover equipment selection and estimation of fuel values; the third describes procedures for evaluating financial aspects. This report is the basis for the third slide-tape presentation. It can be used as a complement to the audiovisual program, or by itself as a guide to analysis of boiler system investments.

The Forest Products Laboratory appreciates the review and suggestions on this report from Monte R. Harold, Tennessee Valley Authority, Division of Forestry, Fisheries, and Wildlife; Eldon M. Estep, U.S. Forest Service, Division of Cooperative Forestry; and Arthur B. Brauner, Executive Vice President of the Forest Products Research Society.

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Explanation......Under the major sections. the numbered items are the titles of specific slides in the slide series.

Preliminary copies of this materical, originally issued in April 1977 as an unnumbered publication, contained an error in handling of investment cdredits. This new report shows that the credit is deducted from taxes, not from income.

T. H. Ellis

ECONOMIC ANALYSIS
OF WOOD- OR BARK-FIRED SYSTEMS

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I. COMPARING ALTERNATE SYSTEMS

1. Main Things the Manager Must Know

Although a detailed economic analysis could be very complex, the basic principle is simple: compare expected costs, year-by-year, for the expected life of the system--for a residue-fueled operation and for the alternative fossil fuel system. To do this, the manager must have year-by-year estimates of:

- Equipment purchase and installation costs
- Annual operating and maintenance costs
- Annual fuel costs
- Annual wood and bark residue disposal costs
- Property taxes and insurance
- Income tax rates

The manager also must know the expected useful lives of the system being compared.

2. A Simple Example--Comparing Alternative Systems

Here are some purely hypothetical figures to demonstrate the general procedure. In this case, it is assumed that a mill manager is planning a new installation and must buy either a fossil-fueled or a residue-fueled system, both assumed to last 10 years. Expected costs are shown below:

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

	System using fossil fuel	Residue-fueled system	Difference in cost
Initial investment (purchase and installation)	$ 50,000	$200,000	+$150,000
Annual fuel costs	200,000	70,000	- 130,000
Annual operating and maintenance costs	5,000	20,000	+ 15,000
Annual residue disposal costs	5,000	0	- 5,000
Expected useful life	10 yrs	10 yrs	

He estimates the cost of purchasing and installing the most suitable system using fossil fuels would be $50,000. For a residue-fueled system, the comparable estimate is $200,000.

Annual fuel costs, based on current prices, are assumed to be $200,000 for fossil fuels or $70,000 for wood or bark residue. The cost for the wood or bark residue would include their value if used as furnish for pulp or other products produced by the firm, or their net sales value if the firm has a market for residue. And it would include the cost of any fossil fuels which might be necessary to supplement wood and bark residues.

Costs of disposing of unsalable mill residues that cannot be used in the fossil-fueled system are assumed to be $5,000 per year. For the residue-fueled operation, no waste-disposal cost is assumed because unsalable residues are burned.

For simplicity's sake, in this example it is assumed that annual operating and maintenance costs include property taxes and insurance.

With this information, the manager can calculate the before tax profitability of the increase in investment cost for the wood- or bark-residue-fueled system.

3. Profitability of the Increased Investment in the Residue-Fueled System

Increase in investment	$150,000
Annual savings for each of next 10 years	$120,000
R.O.I., before taxes	79 percent

R.O.I., after taxes	about 40 percent
Present worth of annual savings at 20 percent discount rate, before taxes	$503,097

The residue-fueled system is expected to cost $150,000 more than the most suitable fossil-fueled alternative in this case. Estimated annual savings in fuel costs would be $130,000. Yearly operating and maintenance costs are assumed to be $15,000 higher for the residue-fueled system, partially offset by savings of $5,000 per year in residue disposal costs.

Thus, for an initial increase in investment of $150,000, annual savings of $120,000 would be expected for the next 10 years. Is the annual savings worth the initial increase in investment? In this case, the obvious answer is yes. Ignoring taxes, the rate of return on investment would be 79 percent. If the firm paid an average of 52 percent state and federal corporate income tax, the after-tax rate of return still would be about 40 percent. Again ignoring taxes, the present value of the annual savings in cost, using a 20 percent interest rate, would be about $503,097--an amount considerably larger than the $150,000 added cost of the wood- or bark-fueled system.

II. TERMS USED IN INVESTMENT ANALYSIS

Several business economics terms were mentioned above and should be explained.

4. Interest Rate

The notion of an interest rate is familiar to anyone who ever borrowed money from a bank or put money into a savings account. It's simply the charge that a person or firm must pay for borrowed money or expect to get from invested money. In practice, however, the firm must consider many different kinds of interest rates. The rate paid for borrowed money may vary, depending on the amount and the length of the loan period. Similarly, the interest rate available to the firm from various sorts of investments will differ according to the risks involved and other factors. The point is, the mill manager must be clear about which interest rate is appropriate for his analysis.

5. <u>Present Worth</u>

Using whatever interest rate is appropriate, the mill manager can calculate the discounted value today of an expected future cost or return or of a series of costs and returns. This value is an estimate of how much it would be worth spending now to avoid a specific unfavorable series of future expenses and incomes or to obtain a desirable series.

For a single future value, present worth is the sum of money which would have to be invested today to produce the expected future amount, with a given interest rate. For example, if the interest rate is 20 percent per year, a payment of $100 expected 5 years hence is worth $40.19 today.

6. <u>R.O.I.--Rate of Return on Investment</u>

Businesses commonly evaluate investment opportunities in terms of R.O.I.: the expected rate of return on investment. R.O.I. is simply the compound interest rate at which the present value of all costs associated with a project is expected to equal present value of all returns.

7. <u>Minimum Acceptable Rate of Return</u>

Many firms set a floor for the lowest R.O.I. they will accept for a particular kind of investment. If a firm has to borrow money to finance the investment, it is not likely to accept a lower expected rate of return than the interest rate on the loan. Even if the firm does not have to borrow money for a project, it should establish a lower limit on R.O.I. which would avoid spending on projects less profitable than others currently available.

III. DETAILED EXAMPLE

a. <u>A More Complicated Example</u>

Evaluate a hypothetical $200,000 residue system as a replacement for one using fossil fuel, considering inflation and taxes: Having gone through a simple example and defined some of the terms involved in economic analysis, let us now consider a more complicated problem. In this case, it is assumed that a decision is being made about replacing an existing furnace and boiler system that uses oil or gas, with one using wood residues.

9. First-Year Cost Comparison

	Residue-fueled system	Present system
Initial investment at start of year	$200,000	$ 0
12 months' fuel cost	70,000	200,000
Operation and maintenance	40,000	10,000
Property tax and insurance	5,000	375

The investment of $200,000 to purchase and install the new system is assumed to be made at the start of the first year. In the first 12 months of operation, fuel costs are expected to be $70,000--including any supplemental oil or gas plus the net sales value of any of the wood or bark residue which might otherwise have been sold or used as furnish for fiber products. Operation and maintenance, including electricity, mechanical, and other repairs, any labor expenses, and costs of operating any mobile equipment needed, are anticipated to be $40,000. Property tax and insurance costs are estimated to be $5,000, based on 2.5 percent of the cost of the installation. In practice, of course, property taxes and insurance rates will depend on local regulations.

Comparable figures for operation of the existing fossil-fuel system are expected to be $200,000 for fuel, $10,000 for operation and maintenance, and $375 for property tax and insurance. It is assumed that this system has a market value of $15,000, for property tax and insurance purposes.

Having made estimates of investment costs and first-year expenses, what the mill manager now must do is to project subsequent costs for the expected useful lifetime of the proposed system--comparing all costs, year by year, with expected costs for continued use of the existing fossil-fueled system.

10. <u>Residue System Costs for Expected Lifetime</u>

Year	Investment	+ Fuels	+ Operation and maintenance	+ Property tax and insurance	= Total cost
0	$200,000				$200,000
1		$ 70,000	$40,000	$5,000	115,000
2		77,000	21,000	4,750	102,750
3		84,700	22,050	4,500	111,250
4		93,170	23,152	4,250	120,572
5		102,487	24,310	4,000	130,797
6		112,736	25,526	3,750	142,012
7		124,009	26,082	3,500	154,311
8		136,410	28,142	3,250	167,802
9		150,051	29,549	3,000	182,600
10		165,056	31,026	2,750	198,832

The initial investment of $200,000 is considered to be at the start of the first year. All other costs are assumed to occur at the end of whatever year in which they come. This is an economists' convention which doesn't have to be followed but is often used to simplify calculations.

For this example, it is assumed that the average value of the wood residues used as fuel will increase at a rate of 10 percent per year, due to increasing demand for pulp and particleboard furnish and for wood and bark fuels. Also, it is assumed that prices of oil and gas will increase 10 percent per year. So the total fuel cost for the proposed system, including the net sales value of the residues plus the cost of supplemental fossil fuels, rises from $70,000 in Year 1 to $165,056 in Year 10.

Costs of operation and maintenance are expected to be relatively high in the first year until the system is completely adjusted. Costs in the second year are assumed to drop, but a subsequent increase of 5 percent per year due to rising labor costs and other factors is expected.

Property tax and insurance costs are assumed to decrease 5 percent per year due to depreciation. For this example, a 20-year straight-line depreciation of installed equipment is assumed. In practice, the firm is likely to have to continue paying property tax and insurance fees as long as the equipment is in operation. It is important to know exactly what local practices are for this.

11. Costs for Continued Operation of Present System

A similar list of expected costs must be prepared for the present system:

Year	Fuels	+	Operation and maintenance	+	Property tax and insurance	=	Total cost
1	$200,000		$10,000		$375		$210,375
2	220,000		10,500		338		230,838
3	242,000		11,025		300		253,325
4	266,200		11,576		263		278,039
5	292,820		12,155		225		305,200
6	322,102		12,763		188		335,053
7	354,312		13,401		150		367,863
8	389,743		14,071		113		403,929
9	428,718		14,775		75		443,568
10	471,590		15,513		38		487,141

No investment cost for the present system is assumed in this example (although in many cases, there might be a substantial cost for overhauling an existing system sometime in the next several years). Fuel prices again are assumed to increase at 10 percent per year and operation and maintenance costs at 5 percent per year. Property tax and insurance costs are estimated on the assumption that the system has a market value of $15,000 at the start of the first year and is worthless at the end of the 10th year,

12. Cash Flow Analysis, Before Income Taxes

Now the manager is prepared to make a cash-flow analysis of the changes in cost for the proposed system as compared to the existing one. He simply subtracts costs expected for the present system from those expected for the wood-residue system.

Year	Costs for residue system	-	Costs for present system	=	Net change in costs
0	$200,000		$ 0		+$200,000
1	115,000		210,375		- 95,375
2	102,750		230,838		- 128,088
3	111,250		253,325		- 142,075
4	120,572		278,039		- 157,467
5	130,797		305,200		- 174,403
6	142,012		335,053		- 193,041
7	154,311		367,863		- 213,552
8	167,802		403,927		- 236,125
9	182,600		443,568		- 260,968
10	198,832		481,141		- 288,309

13. <u>Before-Tax Profitability</u>

Present worth of decrease in costs at 20 percent interest	$673,000
Investment cost	200,000
Net present worth	473,000
Rate of return on investment	64 percent

Using a 20 percent interest rate to discount future cost savings, the manager calculates present worth of these savings to be $673,000 as compared to an investment cost of only $200,000. If the firm uses 20 percent as the minimum attractive rate of return, the project certainly meets that requirement.

Using either a computer program or a more tedious hand calculator and interest tables, the manager can calculate rate of return on investment, which in this case, would be about 64 percent. This means that an interest rate of 64 percent would be required to discount future savings sufficiently to equal expected investment cost, in this example.

To make the net present worth and R.O.I. estimate, the manager needs either a table of compound interest factors, or a computer program specifically designed for this purpose. The computer does very rapidly the same thing that could be done much more slowly by hand--discounting the cash flow at first one trial interest rate and then another, until a rate is found which makes the present worth of future cost savings equal the initial investment cost.

14. <u>Compound Interest Factors</u>

Tables of compound-interest factors are found in many engineering economics textbooks and in government publications. One example is "Tables of Compound-Discount Interest Rate Multipliers for Evaluating Forestry Investments," by Allen L. Lundgren, USDA Forest Service Research Paper NC 51, 1971. Factors for several interest rates are shown below:

Year	@10%	@15%	@20%	@25%
1	1.100	1.150	1.200	1.250
2	1.210	1.322	1.440	1.562
3	1.331	1.521	1.728	1.953
4	1.464	1.749	2.074	2.441
5	1.611	2.011	2.488	3.052
6	1.772	2.313	2.986	3.815
7	1.949	2.660	3.583	4.768
8	2.144	3.059	4.300	5.960
9	2.358	3.518	5.160	7.451
10	2.594	4.046	6.192	9.313

The manager selects the appropriate compound interest factor for each year of future cost savings and divides it into the savings estimate.

15. Calculation of Present Worth @ 20 Percent

Thus the estimated cost saving of $95,375 for the first year is divided by 1.200, the second year's saving by 1.440, and so on. Totaling the present worth estimates for each year, the manager calculates present worth for the expected life of the system to be $672,970, or approximately $673,000.

Year	Decrease in costs ÷	Compound interest factor	= Present worth
1	$ 95,375	1.200	$ 79,479
2	128,088	1.440	88,950
3	142,075	1.728	82,219
4	157,467	2.074	75,924
5	174,403	2.488	70,098
6	193,041	2.986	64,649
7	213,552	3.583	59,601
8	236,125	4.300	54,913
9	260,968	5.160	50,575
10	288,309	6.192	46,562
			$672,970

To calculate R.O.I., the manager could simply try different interest rates until he found one for which the sum of discounted future savings equaled initial investment cost.

IV. EFFECTS OF INCOME TAXES

The manager may wish to evaluate the project. on an after-tax basis, considering the effects of income taxes. He will need to consider three major elements: investment tax credit (if any), depreciation, and taxes on increased profits due to cost savings.

16. Income Tax Factors

Investment credit

Allowable depreciation schedule

Marginal tax rate on profits

17. Tax Assumptions for This Example

Investment credit	10 percent (e.g., 10% x $200,000 = $20,000)
Depreciation schedule	Double-declining--1st 5 years Straight-line--2nd 5 years
Effective state and federal income tax rate	52 percent

For the present example, it is assumed that an investment credit f 10 percent is available in the first year. The allowable credit depends on several factors and may change from year to year, depending on tax legislation. A tax expert's advice may be needed for a specific situation.

Depreciation for income tax purposes may be calculated on a different basis than that used for property taxes or insurance. In the present example, it is assumed that double-declining depreciation is used for the first 5 years and straight-line for the rest of a 10-year lifetime is used. Again, the allowable methods of depreciation may vary from year to year, and according to types of equipment. The effect of depreciation is to reduce the net income on which income taxes are based. For this example, an effective state and federal tax rate of 52 percent is assumed. Therefore, depreciation of $40,000 in the first year is assumed to result in a $20,800 tax reduction, i.e., 52 percent of $40,000.

18. Depreciation on $200,000 Over a 10-Year Period

The method of calculation has a large effect on the depreciation estimate for any one year. Therefore, the firm must be careful in selecting one which will best meet its particular situation.

Year	Double-declining depreciation	Straight-line depreciation
1	$40,000	--
2	32,000	--
3	25,600	--
4	20,480	--
5	16,384	--
6	--	$13,107
7	--	13,107
8	--	13,107
9	--	13,107
10	--	13,107

19. Calculation of Taxable Amount

Subtracting depreciation from expected cost savings, the manager can calculate the taxable amounts of cost savings. For example, the first-year depreciation allowance of $40,000 is subtracted from the estimated $95,375 in cost savings in calculating the taxable amount of savings for Year 1.

Year	Cost saving	Depreciation		Taxable amount
1	$ 95,375	-$40,000	=	$ 55,375
2	128,088	- 32,000	=	96,088
3	142,075	- 25,600	=	116,475
4	157,467	- 20,480	=	136,987
5	174,403	- 16,384	=	158,019
6	193,041	- 13,107	=	179,934
7	213,552	- 13,107	=	200,445
8	236,125	- 13,107	=	223,018
9	260,968	- 13,107	=	247,861
10	288,309	- 13,107	=	275,202

20. Tax Effects

Then the increase in income tax liability can be estimated by applying the expected effective rate, which is assumed to be 52 percent in this example. By this means, a schedule of net tax effects can be prepared. The investment credit of $20,000 is subtracted then from the increase in tax liability.

Year	Taxable amount	Increase in tax liability	Investment credit	Net income in tax
1	$ 55,375	$ 28,795	$-20,000	$ 8,795
2	96,088	49,966	0	49,966
3	116,475	60,567	0	60,567
4	136,987	71,233	0	71,233
5	158,019	82,170	0	82,170
6	179,934	83,565	0	83,565
7	200,445	105,594	0	105,594
8	223,018	118,423	0	118,423
9	247,861	132,213	0	132,213
10	275,202	147,129	0	147,129

21. Cash Flow Analysis, After Taxes

Having calculated the net change in taxes, the mill manager now can calculate after-tax savings. Increases in taxes are subtracted from the respective before-tax cost decreases, year by year. Thus, in the first year, a $95,375 decrease in costs is partially offset by an $8,795 increase in taxes--leading to a $86,580 saving after taxes.

Year	Investment cost	Cost savings	Increase in income tax	After-tax savings
0	$200,000			
1		$ 95,375	$ 8,795	$ 86,580
2		128,088	49,966	78,122
3		142,075	60,567	81,508
4		157,467	71,233	86,234
5		174,403	82,170	92,233
6		193,041	93,565	99,476
7		213,552	105,594	107,958
8		236,125	118,423	117,702
9		260,968	132,213	128,755
10		288,309	147,129	141,180

22. Profitability Measures, Before and After Taxes

From the schedule of cost decreases and after-tax savings, the manager now can evaluate the profitability of the proposed investment for its expected useful lifetime. Present worth of cost savings can be calculated and compared to investment cost. Using the discounting procedure described earlier, and a 20 percent interest rate, he calculates the present worth of expected cost savings to be $672,970 before taxes. For after-tax calculations, a lower interest rate probably would be used to calculate present worth. For this example, 10 percent was used--leading to an estimate of $596,175. Either way, before tax or after tax, the present worth of expected savings would greatly exceed the $200,000 investment cost. Thus, the investment would appear highly profitable.

Present worth of before-tax savings, @ 20 percent	$672,970
Present worth of after-tax savings, @ 10 percent	$596,175

By trial and error, the manager can estimate before- and after-tax R.O.I. In this case, the estimates are 64 percent versus 43 percent--indicating the investment is expected to be highly profitable.

R.O.I., before taxes -- 64 percent

R.O.I., after taxes -- 43 percent

V. RECAPITULATION

The procedure for evaluating a proposed investment is:

23. How to Do It

1. Estimate all cost changes for the expected lifetime of the equipment.

2. Calculate present worth of net yearly savings at the appropriate interest rate.

3. Compare present worth of savings with expected investment cost

   or

4. Calculate R.O.I. and compare with minimum acceptable rate of return.

The primary rule is to calculate all cost changes for each year the equipment is expected to last. This includes not only reductions in oil and gas purchases, but also increases in costs due to lost revenue from wood-bark byproduct sales and increased maintenance and operating costs. Initial investment costs should include not only the equipment costs, but also installation costs and the cost of any downtime expected for the mill while the system is being installed. Cost savings should include the value of avoiding likely shutdowns due to natural gas curtailment. Savings also should include any reductions in solid-waste disposal costs, if the proposed system would use material which otherwise must go to landfill or other disposal at a cost.

Next, using a guiding interest rate appropriate for the firm and for the particular project, the manager must calculate present worth of yearly cost savings. He then compares the expected present worth of savings with initial investment cost. Or he can estimate R.O.I. by trial and error using interest tables, or by computer, and compare the answer with the firm's minimum attractive rate of return--i.e., with the rate of return the firm typically expects to get from investment opportunities of equal risk and importance.

24. Mistakes to Avoid

Forgetting to include net sales value of wood residues as a fuel cost.

Ignoring salvage value of existing equipment.

Counting sunk costs.

Forgetting the cost of any supplemental oil or gas fuels needed with residues.

Ignoring costs of equipment to store residue fuels.

First, some past analyses have neglected to calculate the cost of using wood or bark which could be sold instead or used as furnish for another operation by the firm. Any sales revenue that the firm must forego, because it uses residues for fuels, is a cost.

Another mistake would be to ignore the salvage value of an existing system. If some of this equipment could be resold or reused, its salvage value should be deducted from initial investment cost of the proposed new system. Conversely, any past investment costs not salvageable should be ignored in the analysis; they are "sunk costs."

Many residue-fueled systems require supplemental oil or gas during startup. Furthermore, there may be times of the year when residue volumes are insufficient for fuel needs. Obviously, any costs for supplemental fuels must be included in the analysis. Also, there may be substantial costs required for equipment and/or space for storing residues to be used as fuel.

The examples discussed earlier were simplified to help make them understandable. In practice, a firm might have a much more complicated set of cost changes to consider. Certainly, its tax situation will be different than that assumed for these examples. But the basic principle of the cash flow analysis described here is simple:

COUNT ALL COSTS AND SAVINGS.

VII. WORKSHEETS

Two worksheets are included in this bulletin to aid in analysis.

Worksheet A is designed for recording estimated costs of investment and use, year by year. Two or more copies of this worksheet would be needed: One for the residue-fueled option being considered, and one or more for whatever alternative systems are being considered.

Worksheet B is for calculation of tax effects and present worth, after taxes, of the added investment required for a residue-fueled system. Column 2 of Worksheet B is first calculated by comparing the yearly costs recorded in column 2 of Worksheet A. Column 12 of Worksheet B must be taken from a table of compound interest factors for whatever discount rate the manager's firm considers appropriate.

WORKSHEET A

CALCULATION OF COSTS OF ALTERNATIVE BOILER SYSTEMS

SYSTEM ________________

Year (1)	Total cost this year (2)	Cost of equipment and installation (3)	Salvage value of existing system (4)	Fuels and power costs				Operation and maintenance (9)	Property tax (10)	Insurance (11)	Other (12)
				Residue (5)	Oil (6)	Gas (7)	Electricity (8)				
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WORKSHEET A

CALCULATION OF COSTS OF ALTERNATIVE BOILER SYSTEMS

SYSTEM ______________

Year	Total cost this year	Cost of equipment and installation	Salvage value of existing system	Fuels and power costs				Operation and maintenance	Property tax	Insurance	Other
				Residue	Oil	Gas	Electricity				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
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WORKSHEET B

CALCULATION OF AFTER-TAX CHANGE IN COSTS

Year	Before-tax change in costs	Depre-ciation	Net change in taxable income	Change in tax liability		Investment credit		Net change in tax liability		After-tax change in costs (-) or income (+)	Compound interest factor	Present worth, after taxes
				Federal	State and local	Federal	State and local	Federal (col. 5-7)	State and local (col. 6-8)	(col. 2-9 and 10)		(col. 11 ÷ 12)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
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WORKSHEET B

CALCULATION OF AFTER-TAX CHANGE IN COSTS

Year	Before-tax change in costs	Depre-ciation	Net change in taxable income	Change in tax liability		Investment credit		Net change in tax liability		After-tax change in costs (-) or income (+)	Compound interest factor	Present worth, after taxes
				Federal	State and local	Federal	State and local	Federal (col. 5-7)	State and local (col. 6-8)	(col. 2-9 and 10)		(col. 11 ÷ 12)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
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