

ECONOMICS OF RETROFITTING INDUSTRIAL BOILERS
FROM OIL TO COAL-OIL MIXTURE FIRING

by

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ABSTRACT

The Process Evaluation Office has completed a preliminary cost study of industrial boilers for the Combustion Division, Pittsburgh Energy Technology Center, Department of Energy. The cost of firing No. 6 fuel oil boilers with coal-oil mixtures (COM) of 50 percent by weight coal was determined. For a given set of operating conditions, fuel savings to justify retrofit costs were determined for 100,000-, 500,000-, and 1,000,000-pound-per-hour steam boilers. The sensitivity of retrofit cost to load factors and costs of No. 6 oil was examined.

INTRODUCTION

The economics of retrofitting No. 6 fuel oil industrial boilers to 50 percent by weight coal-oil mixture firing was examined. A low sulfur fuel was assumed so that retrofit would not require stack gas SO₂ scrubbing equipment. Cost sensitivity of boiler size, average load factor, and cost of fuel oil relative to coal was examined.

The annualized cost (operating cost plus income taxes plus return on investment) to retrofit No. 6-oil-fired boilers to COM firing was determined assuming 100 percent equity financing and a discounted cash flow rate of 12 percent. The annualized retrofit cost for three boiler sizes and the fuel savings per million Btu's required for justifying retrofit are given in the following table:

Item	Boiler size, lb/hr		
	100,000	500,000	1,000,000
Annualized cost, 12% DCF.....	\$674,300	\$1,414,200	\$1,977,400
Required fuel savings/MMBtu:			
100% load factor.....	\$0.661	\$0.277	\$0.194
90% load factor.....	.734	.308	.216
80% load factor.....	.825	.346	.242

The 12 percent discounted cash flow (DCF) rate is probably low for a typical industrial setting unless the industry undertaking a project to retrofit to COM is given permission to use accelerated depreciation methods, special tax consideration, or other such incentives. If industry is not given that support, a DCF rate of 18 percent will be more realistic. The following table

¹Mechanical engineer.

gives the annualized cost and required savings per million Btu's assuming an 18 percent DCF rate.

Item	Boiler size, lb/hr		
	100,000	500,000	1,000,000
Annualized cost, 18% DCF.....	\$836,000	\$1,840,200	\$2,484,600
Required fuel savings/MMBtu:			
100% load factor.....	\$0.819	\$0.361	\$0.243
90% load factor.....	.910	.401	.270
80% load factor.....	1.024	.451	.304

Because of their fluctuating nature, raw fuel costs are not included in the operating cost table (table 2) or in the above tabulations. Instead, costs are shown in terms of fuel savings to justify retrofit. These numbers are determined by dividing the annualized cost by the total annual Btu's of fuel required.

The fuel savings of a premium COM over No. 6 oil on a MMBtu basis were calculated assuming the cost for elaborately beneficiated coal is fixed at \$40 per ton and the cost for No. 6 fuel oil is allowed to vary. A mixing charge of \$1.20 per barrel² was added to the raw fuel charge to determine the per-barrel cost of COM. The results of these calculations for different assumed costs of No. 6 fuel oil are tabulated as follows:

Cost per barrel		Cost per MMBtu		
No. 6 oil ¹	COM ²	No. 6 oil	COM	Savings
\$15	\$13.62	\$2.496	\$2.257	\$0.239
20	16.59	3.328	2.740	.588
25	19.44	4.160	3.222	.938

¹18,970 Btu/lb, 316.8 lb/bbl (API gravity 25°).

²16,360 Btu/lb, 368.8 lb/bbl, coal at \$40/ton.

The data from the above tables are summarized in figures 1 and 2 which show a family of curves relating required fuel savings (in dollars per MMBtu) to defray the cost for retrofitting boilers in sizes ranging from 100,000 to 1,000,000 pounds per hour of steam production. The potential fuel cost savings that will be realized in switching from No. 6 fuel oil to COM is also shown. Three examples of fuel savings are shown as horizontal lines, and any portion of a curve falling beneath a given line represents a boiler size that can be profitably retrofitted for a given market value of No. 6 oil. Coal cost was not varied.

RETROFIT DESCRIPTION

The basis for this study was a 100,000 pound per hour boiler that produces steam for heating as illustrated in the flowsheet, figure 3. The larger units assume the same equipment arrangement, but material flow rates are five and ten times larger.

²George, T. J. A Commercial Coal-Oil Preparation Facility: Concepts and Economics Assuming a 50-Percent Mixture (33 Million Barrels per Year). U.S. Dept. of Energy, Process Evaluation Office, FE/EES-79/2, NTIS.

COM is assumed to be stored in the same fuel tanks currently used for storing No. 6 oil. New pumps were considered necessary to handle the more viscous and abrasive COM.

Also, with a change of fuels, the boiler will require new burner tips and fuel trains. This study assumes that all fly ash is carried with the flue gas or that there is provision for removing any small accumulation of bottom ash.

An electrostatic precipitator was used to remove fly ash. Refined cost studies may show that baghouses are more cost effective. That debate was avoided in this study in order to determine the relative effects of size, load factor, and fuel cost.

An induced draft fan was used downstream of the precipitator to compensate for the pressure drop caused by the precipitator.

ECONOMICS

This study is preliminary; therefore, costs presented must be used with caution. However, the cost sensitivity of the variables examined does provide insight into the consequences of retrofitting oil-fired industrial boilers to COM firing.

Operating and Capital Costs

The boilers are assumed to operate on a 24-hour-per-day, 320-day-per-year basis. The operating and capital costs (which exclude fuel charges) are assumed to be costs above those currently incurred in an oil-fired boiler. The capital costs for the equipment necessary to retrofit three different sized boilers are tabulated in table 1. The estimated annual operating costs to operate and maintain this equipment are given in table 2. An effort was made to overstate rather than understate retrofit costs.

Discounted Cash Flow Analysis

The retrofit costs were determined from the operating and capital cost summaries by discounted cash flow analyses. The DCF analysis assumed a one-year construction period, straight-line depreciation, 50-percent Federal plus state and local taxes, and a plant life of 20 years. No salvage value was assumed, but recovery of working capital was.

CONCLUSION

This report is a preliminary study that has shown the economic consequences of retrofitting existing No. 6 fuel oil boilers to COM firing. Without the benefit of an in-depth engineering design of retrofitted boiler facilities, it is impossible to guarantee accurate cost estimates. Architect engineer support to determine accurate retrofit costs is important. But a market assessment of industrial boilers is just as important. Such a study will be necessary to show the numbers of units of sufficient size and load factor which are suitable for profitable retrofit to COM.

This study considered retrofit in terms of one unit at a time. However, to gain the advantage of economies of scale, the stack gases from a group of small boilers might be ducted to one large precipitator. Also, boilers producing higher quality steam were not considered.

Trends do seem to indicate a substantial economic advantage for large boilers to switch to COM firing. The advantage of switching smaller units, 100,000 to 400,000 pounds per hour, is much less clear. However, if a low cost SO₂ removal scheme such as dry sorbent scrubbing with a baghouse is perfected so that coarsely beneficiated coal priced at \$27 per ton would be a satisfactory constituent of COM, then the resulting lowered COM cost would permit more of the smaller units to be profitably retrofitted.

From information in this economic comparison between current use of No. 6 fuel oil and retrofit to COM, it is obvious that the cost for extra pollution control equipment to accommodate COM firing puts COM at the borderline of profitability for many boilers. However, if we take our national energy policy seriously, we will be switching to 100 percent coal firing in many of our boilers. This will require new source environmental regulation with even tighter restrictions including stack gas scrubbing. A plant engineering strategy might be to switch to COM but design the pollution control equipment so that it can be used for the 100 percent-coal-fired boilers that eventually must replace the original oil-fired units. Also, for coal firing, a plant must have room for coal storage and handling equipment. For oil-fired boilers, adding coal handling facilities would be inconvenient or even impossible. Then, COM made either from No. 6 oil or from a synthetic oil would become a very attractive alternate.

TABLE 1. - Retrofit equipment and number of extra personnel required to operate it

Item	Boiler size, lb/hr		
	100,000	500,000	1,000,000
COM pumps.....	\$27,500	\$125,000	\$225,000
Burner tips and fuel train..	275,000	375,000	450,000
Precipitator.....	1,096,200	2,299,600	3,535,700
Fan.....	8,600	40,000	65,000
Ash handling.....	27,500	25,000	225,000
Plant facilities.....	10,800	21,500	33,800
Plant utilities.....	36,000	72,200	113,400
Total construction and plant cost.....	1,481,600	2,958,300	4,647,900
Interest during construction	118,500	236,700	371,800
Subtotal for depreciation.....	1,600,100	3,195,000	5,019,700
Working capital.....	40,000	79,900	125,500
Total investment.....	1,640,100	3,274,900	5,145,200
Additional operators.....	(1)	(2)	(2)

TABLE 2. - Operating cost summary, boiler retrofit equipment

Item	Case I	Case II	Case III
	100,000 lb/hr	500,000 lb/hr	1,000,000 lb/hr
Direct cost:			
Raw material plus utilities	\$14,900	\$74,200	\$148,400
Direct labor.....	66,200	132,500	132,500
Plant maintenance.....	97,200	145,800	243,000
Payroll overhead.....	32,800	59,200	72,200
Operating supplies.....	19,400	29,200	48,600
Subtotal.....	230,500	440,900	644,700
Indirect cost.....	73,100	123,000	169,600
Fixed cost:			
Taxes and insurance.....	44,400	88,700	139,400
Depreciation.....	80,000	159,800	251,000
Total.....	428,000	812,400	1,204,700

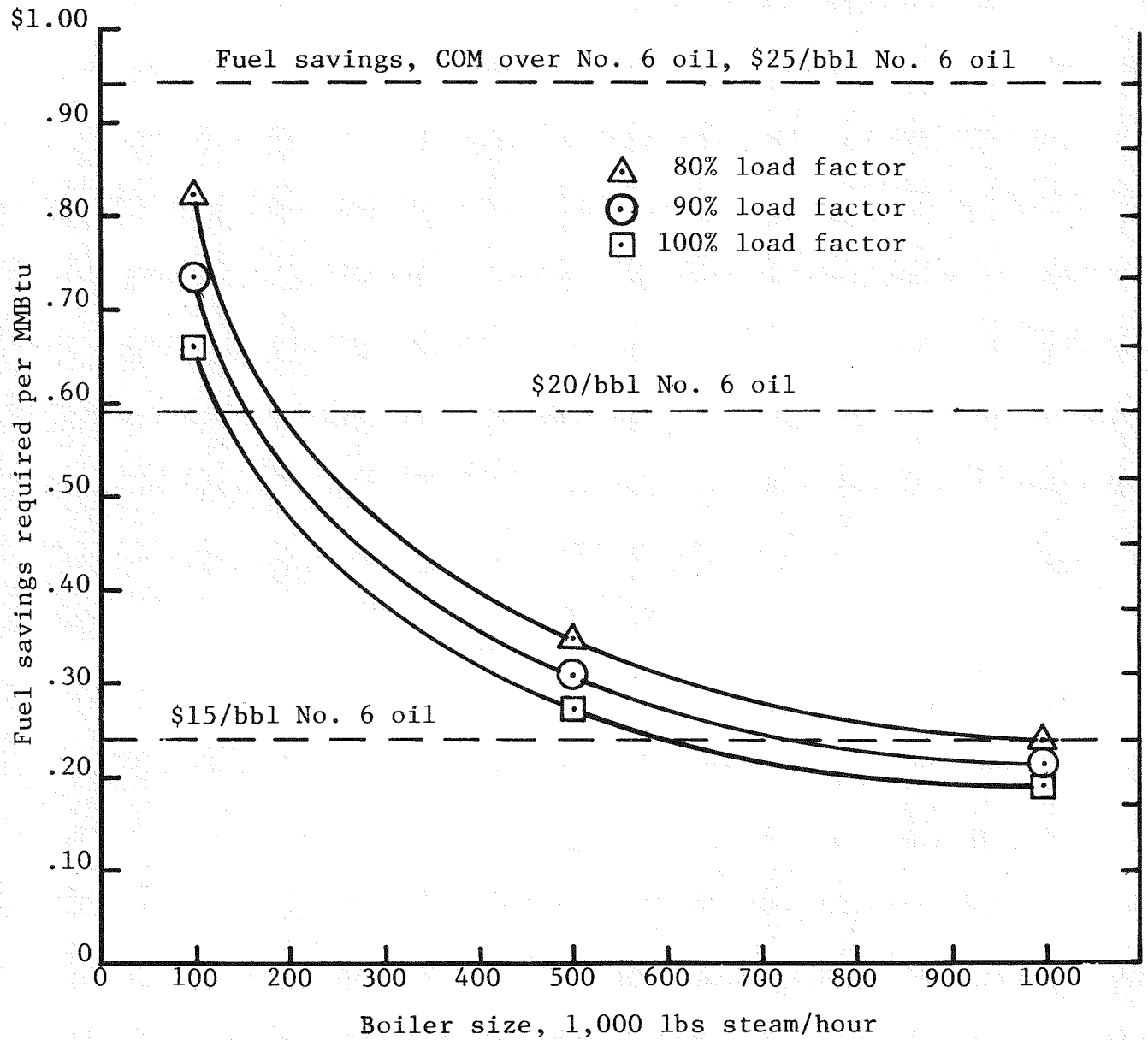


Figure 1. Required Fuel Cost Savings to Justify Retrofit for Boilers (12% DCF, 100% Equity Financing).

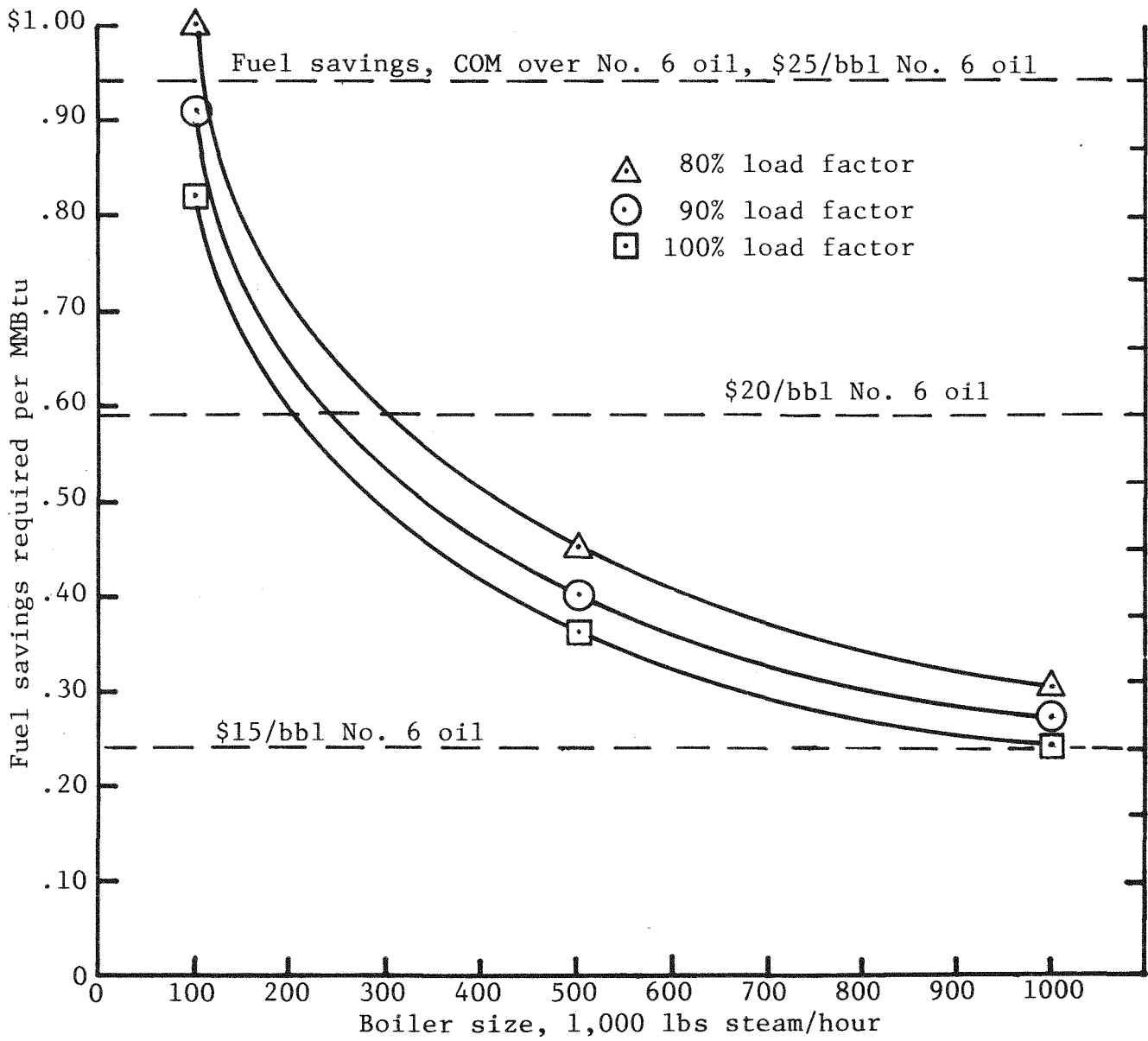


Figure 2. Required Fuel Cost Savings to Justify Retrofit for Boilers (18% DCF, 100% Equity Financing).

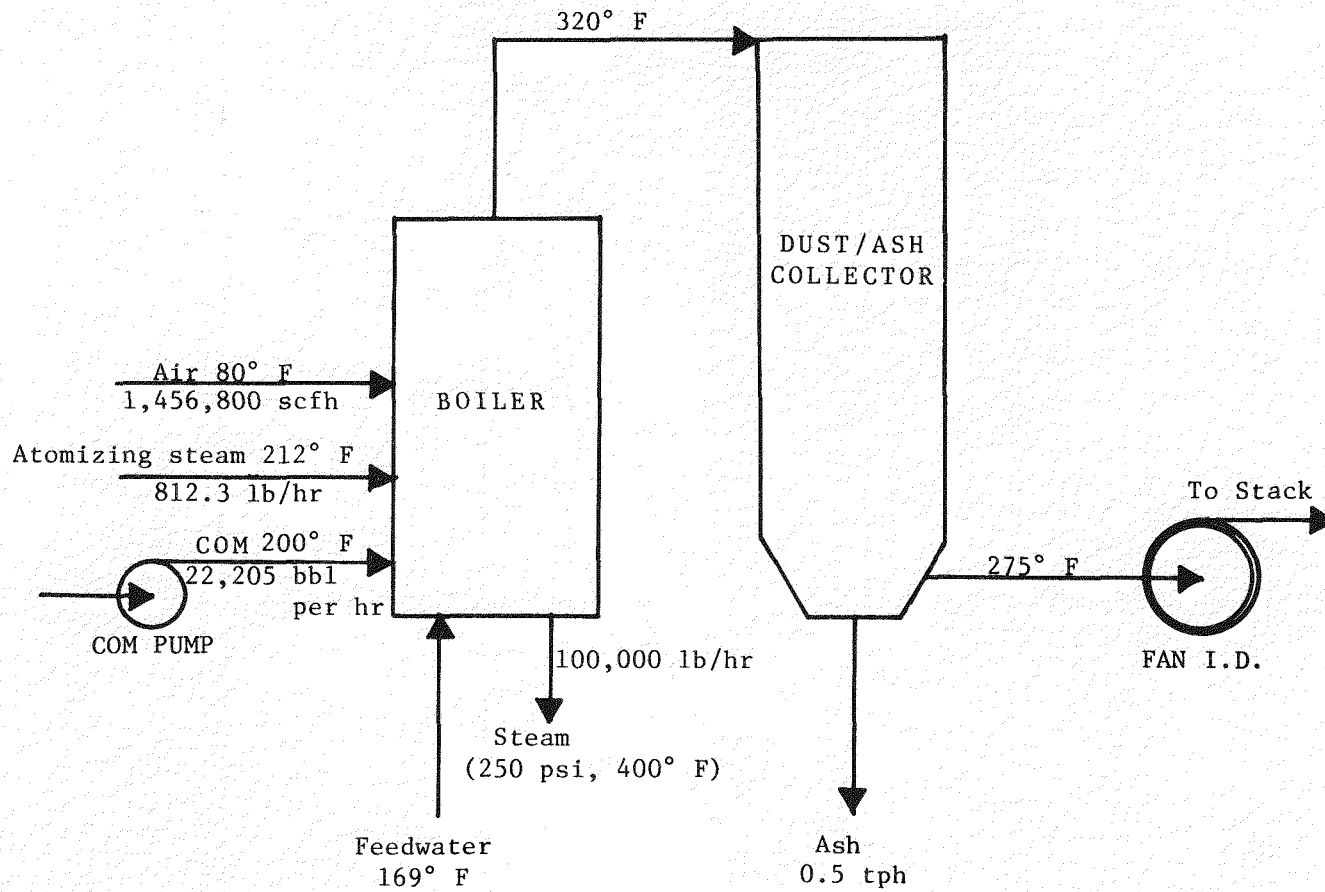


Figure 3. Flowsheet for a Retrofitted Boiler.